
PISO-CM100-D/T

User's Manual

Warranty

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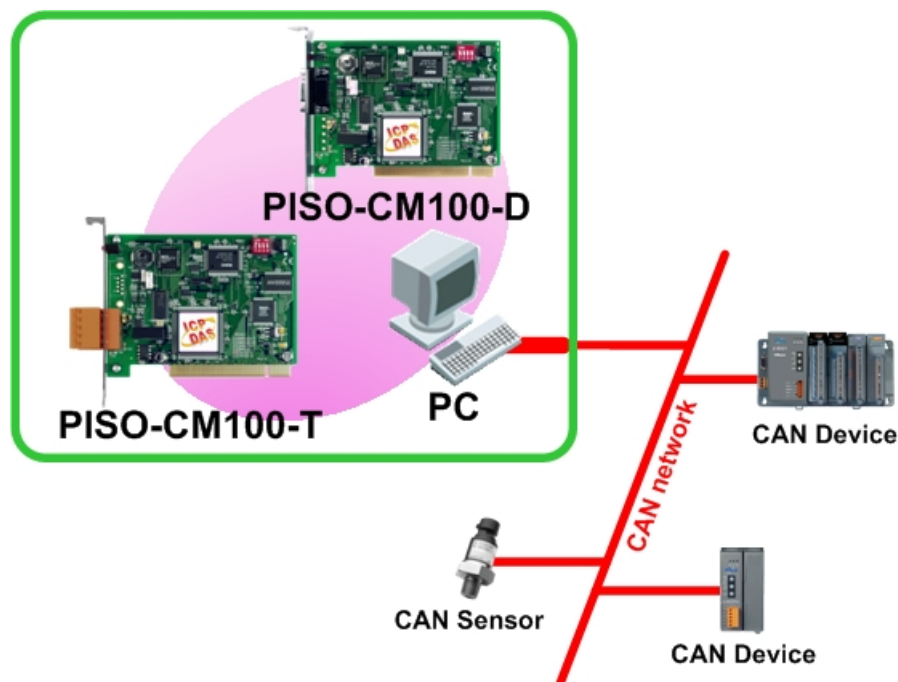
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1 General Information

1.1 Introduction

The CAN (Controller Area Network) is a serial communication protocol, which efficiently supports distributed real-time control with a very high level of security. It is especially suited for networking "intelligent" devices as well as sensors and actuators within a system or sub-system. In CAN networks, there is no addressing of subscribers or stations in the conventional sense, but instead prioritized messages are transmitted. As a stand-alone CAN controller, PISO-CM100 represents a powerful and economic solution. The PISO-CM100 with a 186 CPU inside has one CAN bus communication port with either a 5-pin screw terminal connector or a 9-pin D-sub connector. It can be used as master/slave function to cover a wide range of CAN applications. In addition, the PISO-CM100 uses the new Phillips SJA1000T and transceiver 82C250/251, which provide the bus arbitration and error detection. It can be installed in a 5V 32-bit PCI slot and is supported with actual "Plug & Play" technology.



1.2 Features

- 33MHz 32bit 5V PCI bus (V2.1) plug and play technology
- Follow ISO11898-2 specification
- Philip SJA1000T CAN controller
- Philip 82C250 CAN transceiver
- CAN controller frequency :16 MHz
- 2500Vrms photo-isolation protection on CAN side
- Jumper select 120Ω terminator resistor for CAN bus
- One CAN communication port
- Compatible with CAN specification 2.0 parts A and B
- Provide default baud 10Kbps, 20Kbps, 50Kbps, 125Kbps, 250Kbps, 500Kbps, 800Kbps, and 1Mbps
- Allow user-defined baud
- 2048 records reception buffer and 256 records transmission buffer
- Cyclic transmission precision: $\pm 0.5\text{ms}$ precision when cyclic time is below 10ms , $\pm 1\%$ error when cyclic time exceeds 10ms.
- Provide 5 sets of cyclic transmission.
- Timestamp of CAN message with at least $\pm 1\text{ms}$ precision
- 186 compactable CPU inside
- 8K bytes DPRAM inside
- RTC(Real Time Clock) inside
- 2 indication LED (one for green and another for red)
- Support user-defined firmware
- Support firmware update
- VC++, VB, BCB demos and libraries are given
- C/C++ function libraries of firmware side is given
- Driver supported for Windows 98/Me/NT/2000/XP

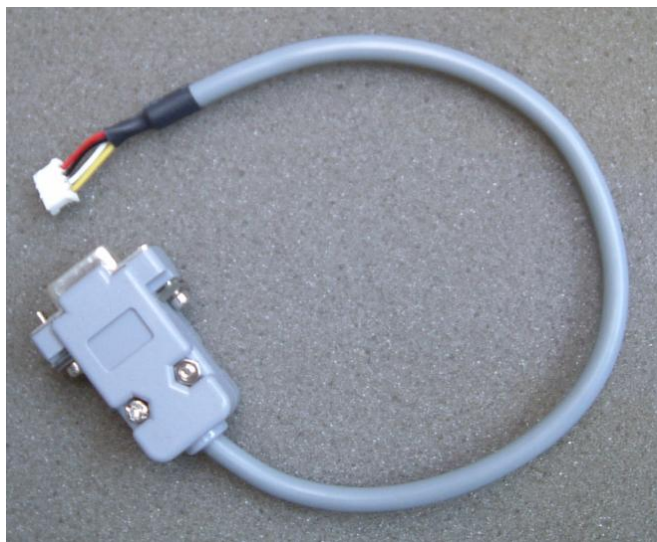
1.3 Specifications

- CAN controller: Phillips SJA1000T
- CAN controller frequency :16 MHz
- CAN transceiver: Phillips 82C250.
- Follow ISO11898-2 specification
- One CAN communication port
- Compatible with CAN specification 2.0 parts A and B
- Jumper select 120Ω terminator resistor for CAN bus
- Provide default baud 10Kbps, 20Kbps, 50Kbps, 125Kbps, 250Kbps, 500Kbps, 800Kbps, and 1Mbps
- Allow user-defined baud
- Connector: 5-pin screw terminal connector or 9-pin D-sub male connector.
- Isolation voltage: 2500Vrms on CAN side
- 33MHz 32bit 5V PCI bus (V2.1) plug and play technology
- 186 compactable CPU
- 8K bytes DPRAM (1K bytes for system)
- 512 K bytes Flash memory (128K bytes for system, others for firmware)
- 512K bytes SRAM
- RTC (real time clock) inside
- 2K EEPROM (256 bytes for system)
- 31 bytes NVRAM
- Power requirements:
5V@400mA
- Environment:
Operating temp: 0~60°C
Storage temp: -20~80°C
Humidity: 0~90% non-condensing
Dimensions: 127mm X 121mm

1.4 Product Check List

Besides this manual, the package includes the following items:

- ☐ PISO-CM100 CAN card
- ☐ Software CD ROM
- ☐ Quickstart
- ☐ One debug cable (model number is 4PCA-0904)



It is recommended that users read the release note first. All the important information needed will be provided in the release note as following:

- ☐ Where you can find the software driver, utility and demo programs.
- ☐ How to install software & utility.
- ☐ How to program users' applications with PISO-CM100 D/T.
- ☐ The definitions of function library, error code, LED status, and pin assignment.
- ☐ The basic solution of troubleshooting.

Attention !

If any of these items are missing or damaged, please contact your local field agent. Keep aside the shipping materials and carton in case you want to ship or store the product in the future.

2 Hardware Configuration

This section will describe the hardware settings of the PISO-CM100. This information includes the wire connection and terminal resistance configuration for the CAN network.

2.1 Board Layout

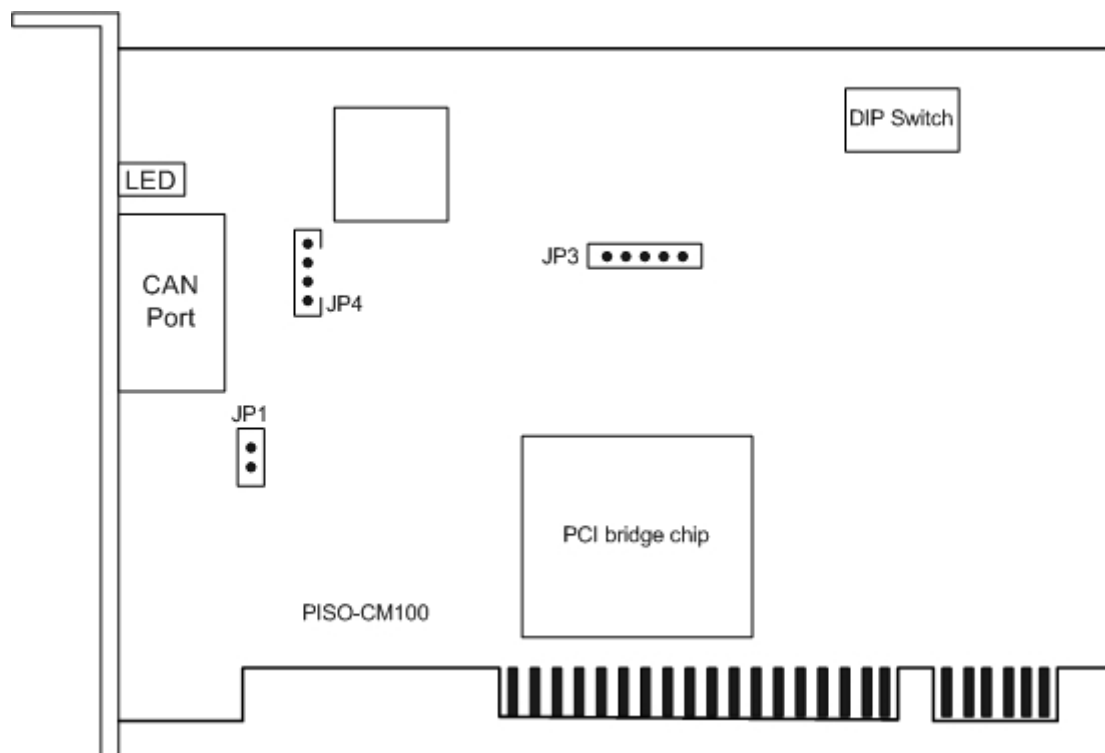


Figure2.1 PISO-CM100-D board layout

Note: PISO-CM100-T layout is similar with PISO-CM100-D. The only difference is the position of CAN port connector. The positions of jumper or DIP switch are the same. Therefore, users can also refer to the PISO-CM100-D layout to configure the jumper or DIP switch if they use PISO-CM100-T.

2.2 Jumper Selection

The following table shows the definition of jumpers or DIP switch. Users need to refer to this table to configure the PISO-CM100- D/T hardware.



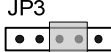
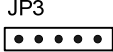

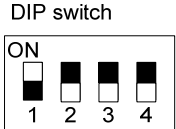
Jumper	Description	Status
JP1	CAN Port 120 Ω terminal resistance.	  Enable Disable
JP3	Reset pin for download error. If users want to update firmware but the process is fail, users can enable this jumper to reset the PISO-CM100-D/T into download mode.	  Enable Disable
JP4	Debug port for user-defined firmware. Users can connect the debug port with the PC RS-232 port via the debug cable.	 4-pin connector for JP4 D-Sub 9 pin connector for PC RS-232 port
DIP switch	DIP switch is used to set the PISO-CM100 board No. Switch1 is for bit0, switch2 is for bit1 and so forth. For example, if the left-hand-side switch (switch 1) is ON, the board No. is set to 1. The range of board No. is from 0 to 15. Be careful that the board No. for each PISO-CM100-D/T, PISO-DNM 100-D/T and PISO-CPM100-D/T must be unique in the PC.	 This situation indicates the board No. 1.

Table 2.1 Jumper or DIP switch selections

2.3 Connector Pin Assignment

The PISO-CM100-T is equipped with one **5-pin screw terminal connector** and the PISO-CM100-D is equipped with one **9-pin D-sub male connector** for wire connection of the CAN bus. The connector's pin assignment is specified as following:

2.3.1 5-pin screw terminal connector

The 5-pin screw terminal connector of the CAN bus interface is shown in Figure 2.2. The details for the pin assignment are presented in Table 2.2.

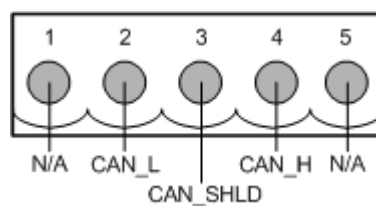


Figure2.2 5-pin screw terminal connector

Pin No.	Signal	Description
1	N/A	No use
2	CAN_H	CAN_H bus line (dominant high)
3	CAN_SHLD	Optional CAN Shield
4	CAN_L	CAN_L bus line (dominant low)
5	N/A	No use

Table 2.2: Pin assignment of 5-pin screw terminal connector

2.3.2 9-pin D-sub male connectors

The 9-pin D-sub male connector of the CAN bus interface is shown in Figure 2.3 and the corresponding pin assignments are given in Table 2.3.

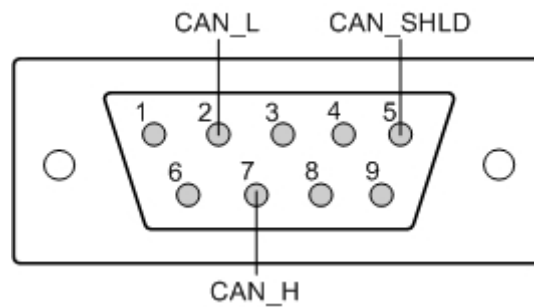


Figure2.3 9-pin D-sub male connector

Pin No.	Signal	Description
1	N/A	No use
2	CAN_L	CAN_L bus line (dominant low)
3	N/A	No use
4	N/A	No use
5	CAN_SHLD	Optional CAN Shield
6	N/A	No use
7	CAN_H	CAN_H bus line (dominant high)
8	N/A	No use
9	N/A	No use

Table 2.3 Pin assignment of the 9-pin D-sub male connector

2.3.3 Wire connection

In order to minimize the reflection effects on the CAN bus line, the CAN bus line has to be terminated at both ends by two terminal resistances as in the following figure. According to the ISO 11898-2 spec, each terminal resistance is 120Ω (or between 108Ω~132Ω). The length related resistance should have 70 mΩ/m. Users should check the resistances of the CAN bus, before they install a new CAN network.

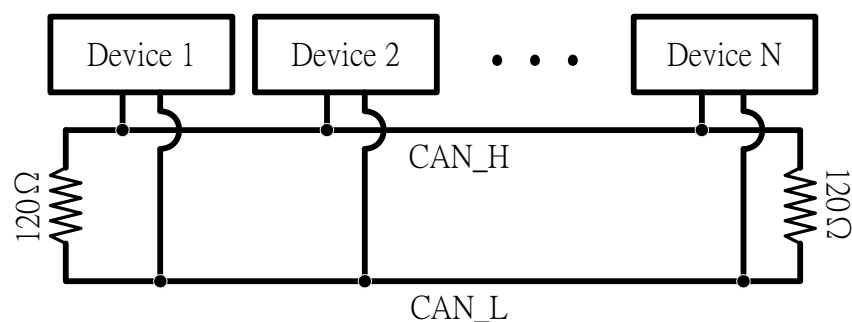


Figure 2.4 CAN bus network topology

Moreover, to minimize the voltage drop over long distances, the terminal resistance should be higher than the value defined in the ISO 11898-2. The following table can be used as a good reference.

Bus Length (meter)	Bus Cable Parameters		Terminal Resistance (Ω)
	Length Related Resistance (mΩ/m)	Cross Section (Type)	
0~40	70	0.25(23AWG)~ 0.34mm ² (22AWG)	124 (0.1%)
40~300	< 60	0.34(22AWG)~ 0.6mm ² (20AWG)	127 (0.1%)
300~600	< 40	0.5~0.6mm ² (20AWG)	150~300
600~1K	< 20	0.75~0.8mm ² (18AWG)	150~300

Table 2.4 Relationship between cable characteristics and terminal resistance

2.4 LED Indicator & PISO-CM100-D/T Mode

The LED status will be changed when PISO-CM100-D/T is in different mode. There are three modes, and each mode describes as following:

1. Download mode: In this case, Green LED and red LED will flash once per second. (When green LED is ON, red LED is OFF. When red LED is ON, green LED is OFF). At the same time, PISO-CM100-D/T will prepare to update the firmware from Utility. Therefore, users can use Utility to download the newer default firmware or the user-defined firmware.
2. Firmware mode: If PISO-CM100-D/T uses default firmware, the green LED will be flashed once when PISO-CM100-D/T receive or transmit one CAN message to CAN bus successfully. If bus loading is heavy, the green LED will turn on always. When some error occurs, the red LED will turn on. Users can use CM100_Status() function to get the situation except buffer status. Reading or sending CAN messages can get the buffer status from the return code of functions. If PISO-CM100-D/T uses user-defined firmware, users can design the green LED or red LED status by themselves.
3. Firmware reset mode: If users enable JP3 described in section 2.2, both red and green LED will turn on about 1 second. At the same time, PISO-CM100-D/T is forced to enter download mode. When PISO-CM100-D/T is out of control because of user-defined firmware or some problems, use this method to reset firmware and download newer firmware again.

2.5 Hardware Installation

When users want to use PISO-CM100-D/T, the hardware installation needs to be finished as following steps.

1. Shutdown your personal computer.
2. Configure the DIP switch and JP1 of the PISO-CM100-D/T for the board No. and the terminal resistance. The more detail information could be found on the figure 2.1 and table 2.1.
3. Check JP3 and JP4 status of PISO-CM100-D/T. If necessary, enable them.
4. Find an empty PCI slot for the PISO-CM100-D/T on the mother board of the personal computer. Plug the configured PISO-CM100-D/T into this empty PCI slot.
5. Plug the CAN bus cable(s) into the 5-pin screw terminal connector or the 9-pin D-sub connector.

When the procedure described above is completed, turn on the PC.

3 Driver Introduction

3.1 Software Installation

The PISO-CM100-D/T can be used in Windows 98/Me/NT/2000/XP environments. Users need to get proper driver for their operation system. These drivers are in Field Bus CD in the PISO-CM100-D/T package. The path is CAN\PCI\PISO-CM100. Also, users can find them from our website as following.

http://www.icpdas.com/download/can/PCI_Interface.htm

The recommended installation procedure is given as below:

Step 1: Shut down your PC.

Step 2: Plug your PISO-CM100-D/T into an available PCI slot.

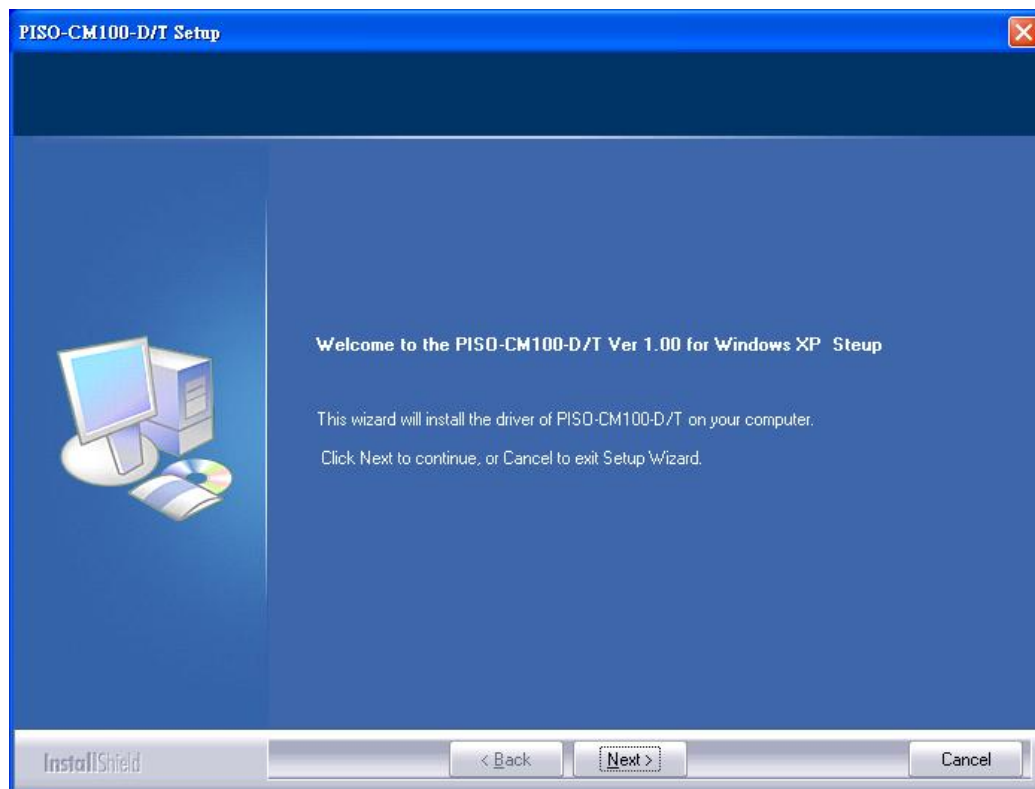
Step 3: Boot up your PC. When system detects a new card and pop up a wizard dialog for driver installation, cancel this dialog and skip the procedure of driver installation.

Step 4: Get the proper PISO-CM100-D/T driver for your operation system. These drivers can be found in CD of PISO-CM100-D/T package or our website.

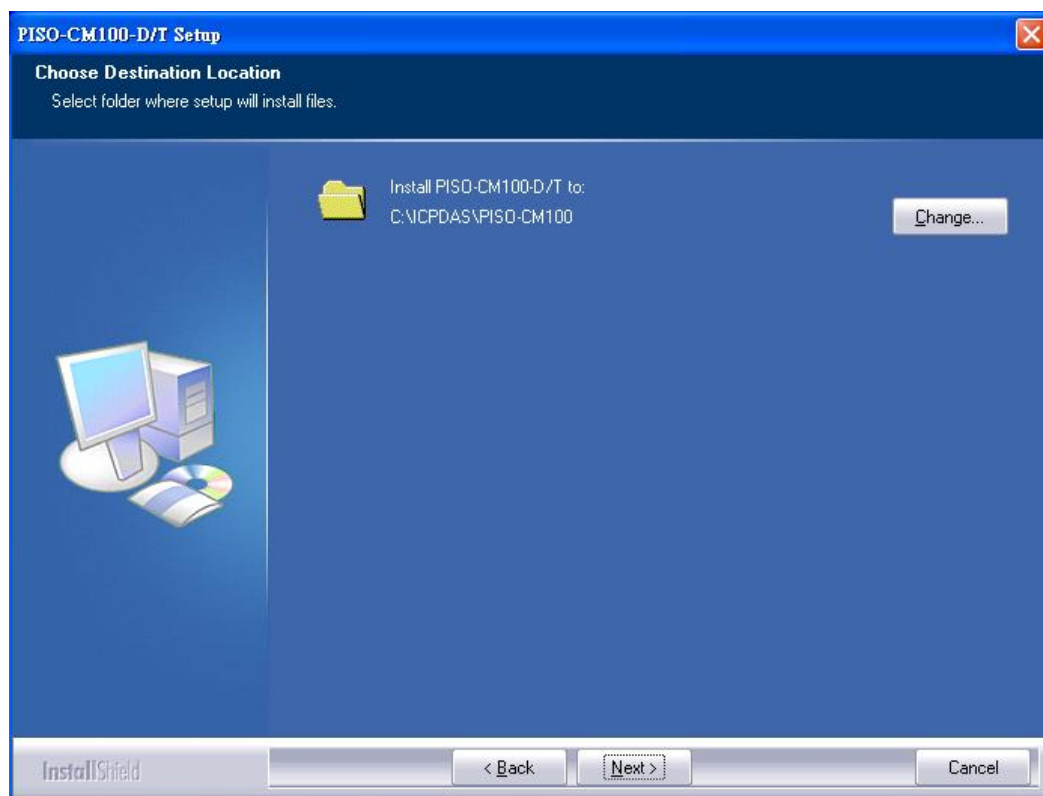
Step 5: Install the driver and reboot your PC. In the following description, the installation procedure for Windows XP is given for an example. The installation procedure for other operation system is similar with the one for Windows XP. Please refer to the installation procedure of Windows XP.

The driver installation procedure for Window XP is shown as below:

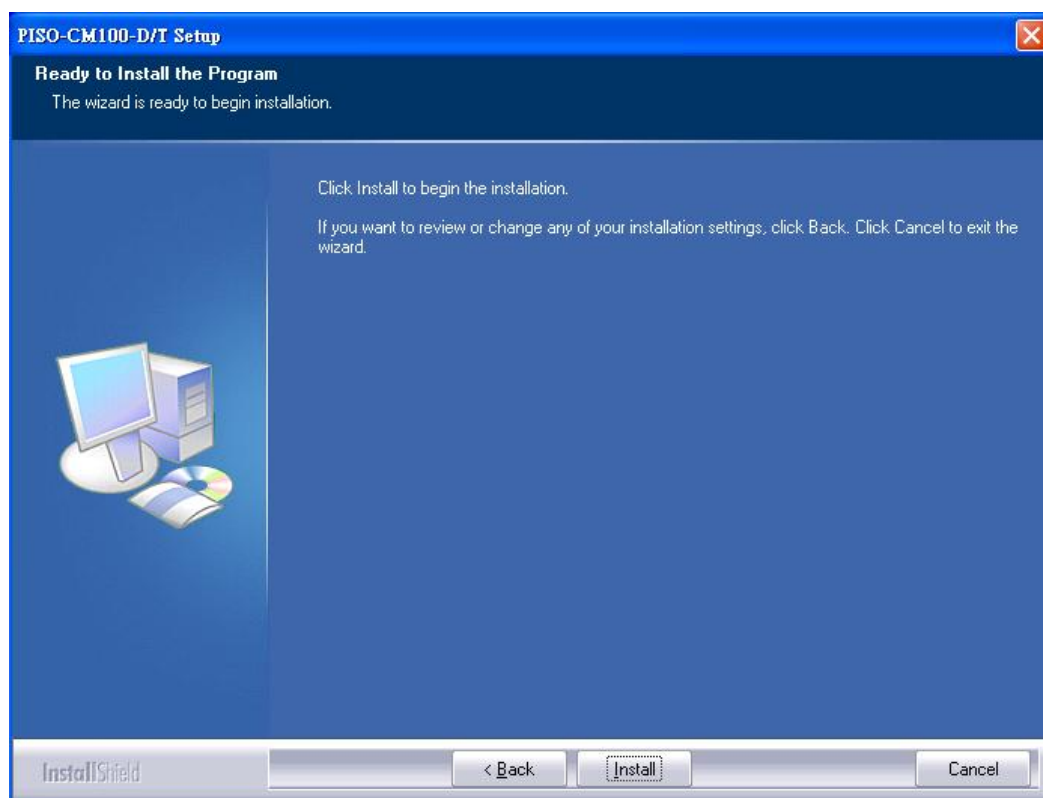
Step1: Execute PISO-CM100.exe file. Then, the installation procedure starts.



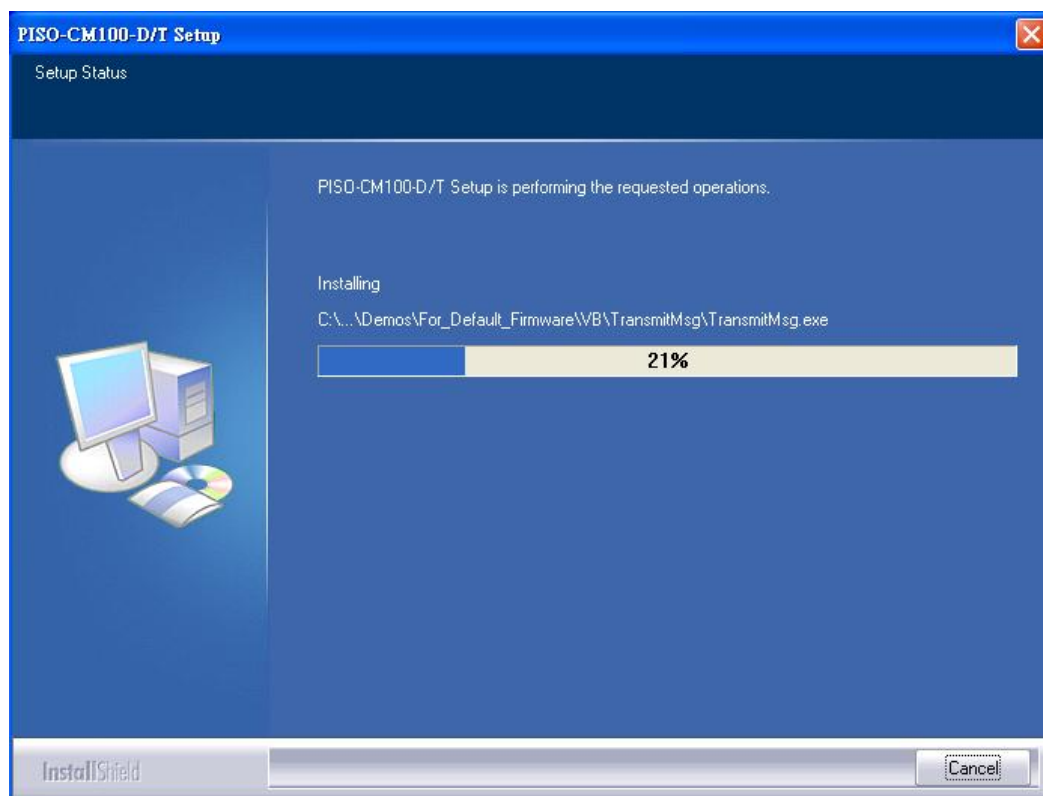
Step2: Confirm the driver installation path. This may concern with where the demos, debug and utility tools are.



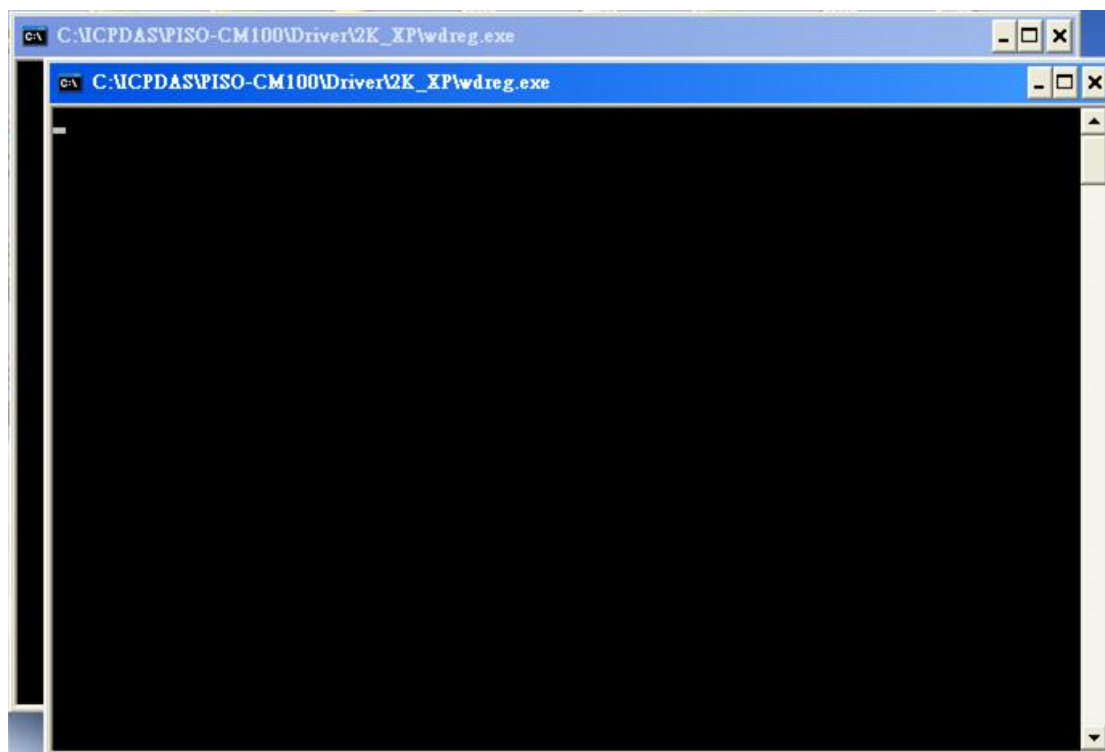
Step3: Click Install button to continue.



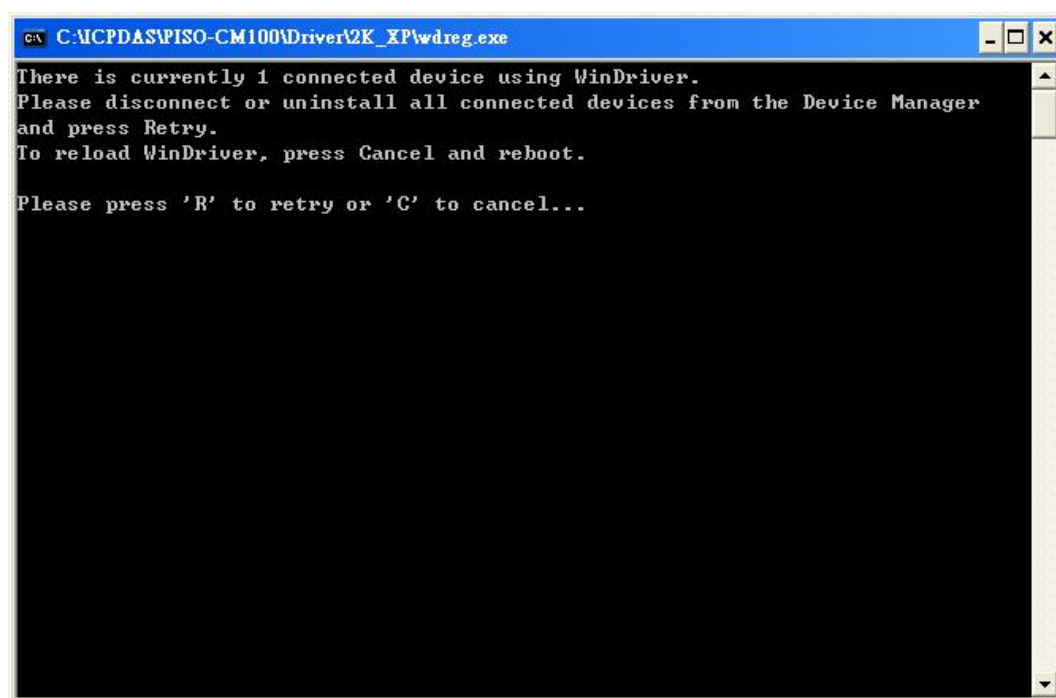
Step4: Afterwards, the files of driver and tools are copied to your disk.



Step5: When finishing the installation, the register procedures are running in two consult dialogs. Please wait until these consult dialogs are finished.



Step6: If users had installed the driver for PISO-CAN200, PISO-CAN400 or PISO-CM100 series boards. One of register dialog may look like following figure. Just ignore the message and close the dialog.



Step7: When all procedures are finished, reset your PC to enable the PISO-CM100-D/T driver.



3.2 Software Architecture

The basic software architecture of PISO-CM100-D/T is shown in the following figure. The Windows 98/Me/NT/2000/XP APIs for PISO-CM100-D/T are provided by cm100.dll. Users can apply this dll file in VC++, VB and Borland C++ Builder to create the Windows applications. Through the kernel driver, KP_CM100.sys and windrvr6.sys, The Windows applications communicate with PISO-CM100-D/T via PCI bus and DPRAM.

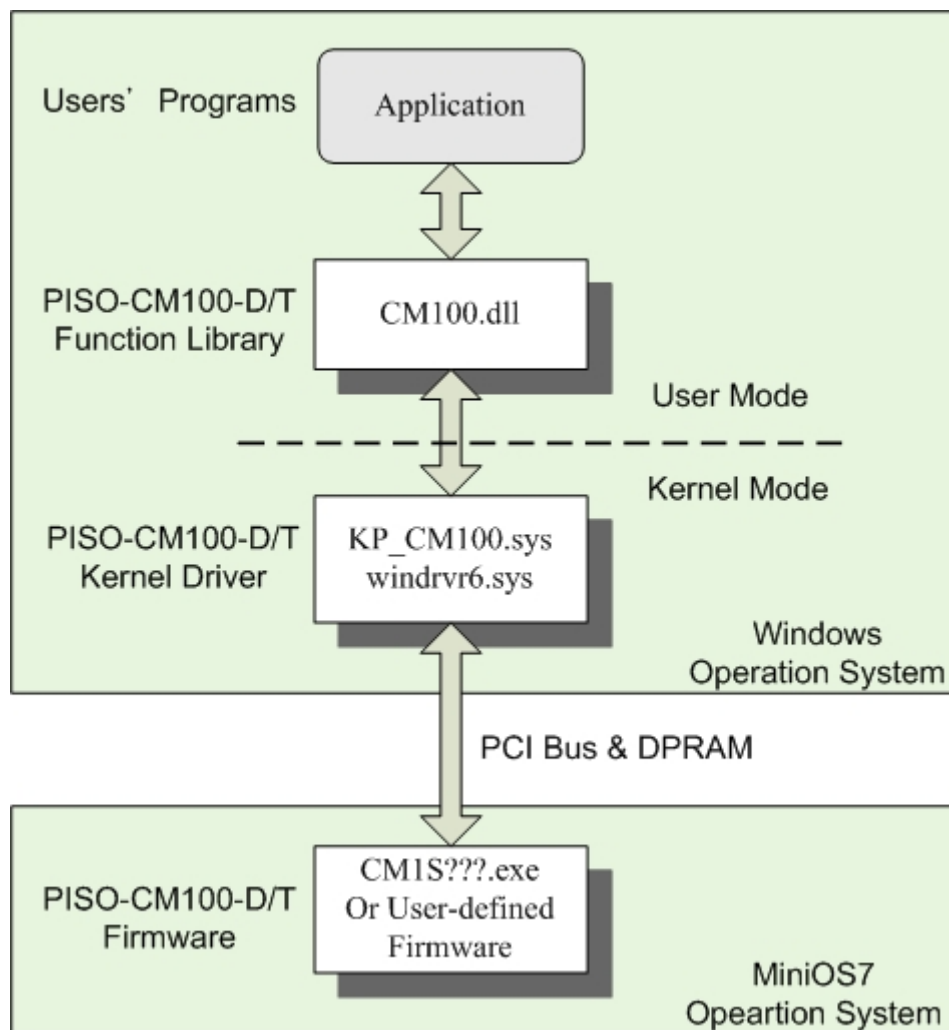


Figure 3.1 PISO-CM100-D/T Basic Software Architecture

Except the PISO-CM100-D/T provides the basic functions for the general purpose applications, users can even design their special firmware for various CAN applications. If users just need the general functions, apply the APIs marked with "<for default firmware>" to build their Windows applications. By applying these APIs, users can configure the CAN controller, get the status of

CAN controller, send/receive CAN messages to/from CAN bus and send CAN messages with cyclic transmission engine. These features help users to reach the purposes of bus monitor, bus access, network debugging, basic network set up ... and etc. The software architecture is shown below.

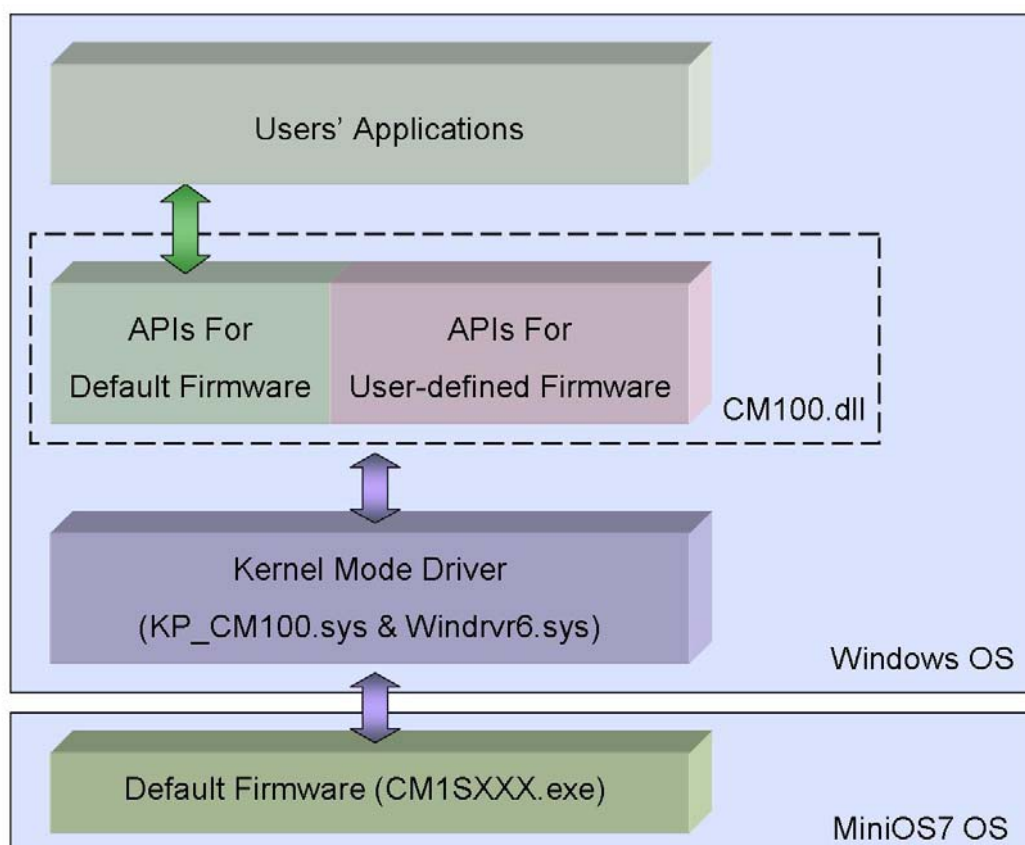


Figure 3.2 PISO-CM100-D/T Default Firmware Software Architecture

Besides, for some special applications, PISO-CM100-D/T provides the flexibilities to arrange the user-defined firmware. This feature may be helpful and powerful for some applications which have complex application protocols or need to improve the system efficiency. Users can interpret the raw CAN messages by the pre-defined application protocols on MiniOS7 platform, and feedback the useful and simplified data to users' Windows applications. This software architecture can have the real-time processing feature, increase the execution performance and efficiently reduce the PC CPU loading. The software architecture is shown below.

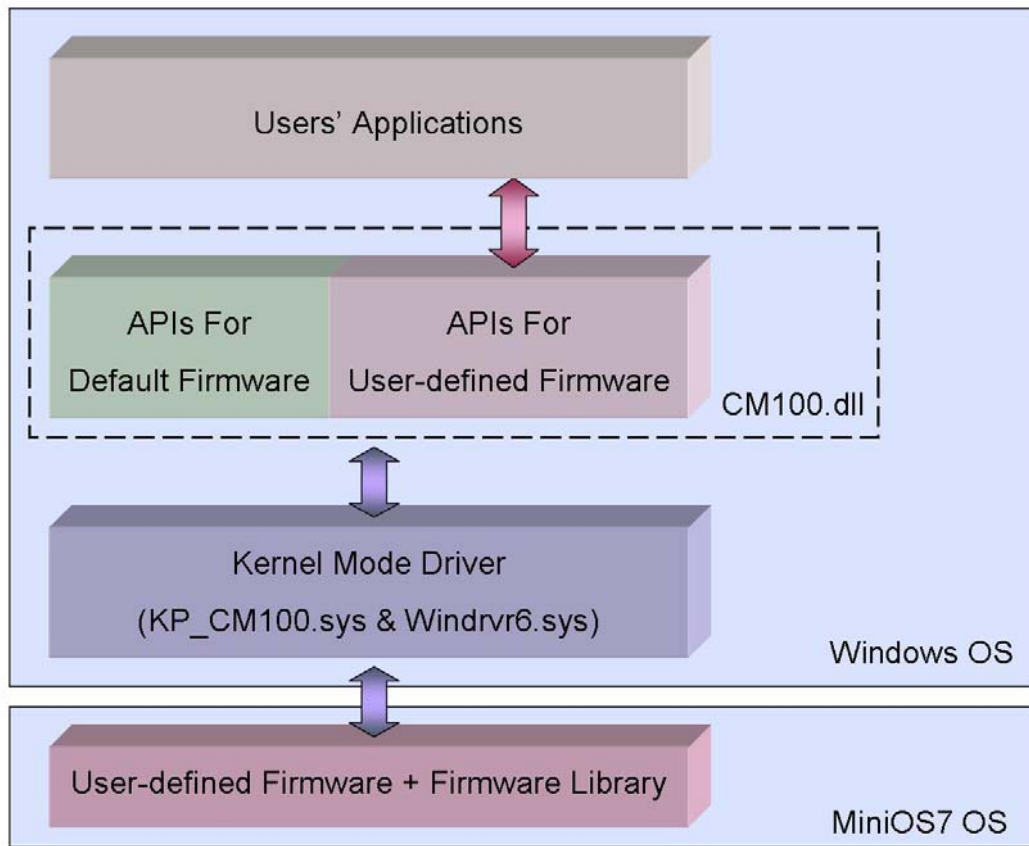


Figure 3.2 PISO-CM100-D/T User-defined Firmware Software Architecture

4 APIs for Windows Application

In this chapter, the APIs for both default firmware and user-defined firmware are described. The content includes the CM100.dll APIs introductions, error code description and the simple method of troubleshooting. It is helpful to development users' application. The section 4.1 shows the list and information of all APIs supported by CM100.dll. The section 4.2 shows the explication of the return codes of the API functions. It can help users to have the basic troubleshooting.

4.1 Windows API Definitions and Descriptions

All the functions provided by the CM100.dll are listed in the following table and the detailed information for every function presented in the following sub-section.

Function definition	Page	Note
WORD CM100_GetDllVersion(void)	29	○△
Int CM100_GetBoardInf(BYTE BoardNo, DWORD *dwVID, DWORD *dwDID, DWORD *dwSVID, DWORD *dwSDID, DWORD *dwSAuxID, DWORD *dwIrqNo)	30	○△
Int CM100_TotalBoard(void)	31	○△
Int CM100_TotalCM100Board(void)	31	○△
Int CM100_TotalDNM100Board(void)	32	○△
Int CM100_TotalCPM100Board(void)	32	○△
Int CM100_GetCM100BoardSwitchNo(BYTE BoardCntNo, BYTE *BoardSwitchNo)	33	○△
Int CM100_GetDNM100BoardSwitchNo(BYTE BoardCntNo, BYTE *BoardSwitchNo)	34	○△
Int CM100_GetCPM100BoardSwitchNo(BYTE BoardCntNo, BYTE *BoardSwitchNo)	35	○△
Int CM100_GetCardPortNum(BYTE BoardNo, BYTE *bGetPortNum)	36	○△
Int CM100_ActiveBoard(BYTE BoardNo)	37	○△
Int CM100_CloseBoard(BYTE BoardNo)	38	○△
int CM100_BoardIsActive(BYTE BoardNo)	39	○△

Function definition	Page	Note
int CM100_AdujstDateTime(BYTE BoardNo)	40	○△
int CM100_Reset(BYTE BoardNo, BYTE Port)	41	○△
int CM100_Init(BYTE BoardNo, BYTE Port)	42	○△
int CM100_HardwareReset(BYTE BoardNo, BYTE Port)	43	○△
int CM100_Check186Mode(BYTE BoardNo, BYTE *Mode)	44	○△
int CM100_Status(BYTE BoardNo, BYTE Port, BYTE *bStatus)	45	○△
int CM100_AddCyclicTxMsg(BYTE BoardNo, BYTE Port, BYTE Mode, DWORD MsgID, BYTE RTR, BYTE DataLen, BYTE *Data, DWORD TimePeriod, BYTE *Handle)	47	○△
int CM100_DeleteCyclicTxMsg(BYTE BoardNo, BYTE Port, BYTE Handle)	49	○△
int CM100_EnableCyclicTxMsg(BYTE BoardNo, BYTE Port, BYTE Handle)	50	○△
int CM100_DisableCyclicTxMsg(BYTE BoardNo, BYTE Port, BYTE Handle)	51	○△
void CM100_OutputByte(BYTE BoardNo, BYTE Port, WORD wOffset, BYTE bValue)	52	○△
BYTE CM100_InputByte(BYTE BoardNo, BYTE Port, WORD wOffset)	53	○△
int CM100_ClearSoftBuffer(BYTE BoardNo, BYTE Port)	54	○
int CM100_ClearBufferStatus(BYTE BoardNo, BYTE Port)	55	○
int CM100_ClearDataOverrun(BYTE BoardNo, BYTE Port)	56	○
int CM100_Config(BYTE BoardNo, BYTE Port, ConfigStruct *CanConfig)	57	○
int CM100_ConfigWithoutStruct(BYTE BoardNo, BYTE Port, DWORD AccCode, DWORD AccMask, BYTE BaudRate, BYTE BT0, BYTE BT1)	60	○
int CM100_RxMsgCount(BYTE BoardNo, BYTE Port)	61	○
int CM100_ReceiveMsg(BYTE BoardNo, BYTE Port, PacketStruct *CanPacket)	62	○
int CM100_ReceiveWithoutStruct(BYTE BoardNo, BYTE Port, BYTE *Mode, DWORD *MsgID, BYTE *RTR, BYTE *DataLen, BYTE *Data , DWORD *UpperTime , DWORD *LowerTime)	64	○
int CM100_SendMsg(BYTE BoardNo, BYTE Port, PacketStruct *CanPacket)	66	○
int CM100_SendWithoutStruct(BYTE BoardNo, BYTE Port, BYTE Mode, DWORD MsgID, BYTE RTR, BYTE DataLen, BYTE *Data)	67	○

Function definition	Page	Note
int CM100_SJA1000Config(BYTE BoardNo, BYTE Port, DWORD AccCode, DWORD AccMask, BYTE BaudRate, BYTE BT0, BYTE BT1)	69	△
int CM100_DPRAMInttToCM100(BYTE BoardNo, BYTE Port, BYTE Data)	70	△
int CM100_DPRAMWriteByte(BYTE BoardNo, BYTE Port, WORD Address, BYTE Data)	71	△
int CM100_DPRAMWriteWord(BYTE BoardNo, BYTE Port, WORD Address, WORD Data)	72	△
int CM100_DPRAMWriteDword(BYTE BoardNo, BYTE Port, WORD Address, DWORD Data)	73	△
int CM100_DPRAMWriteMultiByte(BYTE BoardNo, BYTE Port, WORD Address, BYTE *Data, WORD DataNum)	74	△
int CM100_DPRAMReadByte(BYTE BoardNo, BYTE Port, WORD Address, BYTE *Data)	75	△
int CM100_DPRAMReadWord(BYTE BoardNo, BYTE Port, WORD Address, WORD *Data)	76	△
int CM100_DPRAMReadDword(BYTE BoardNo, BYTE Port, WORD Address, DWORD *Data)	77	△
int CM100_DPRAMReadMultiByte(BYTE BoardNo, BYTE Port, WORD Address, BYTE *Data, WORD DataNum)	78	△
int CM100_DPRAMMemset(BYTE BoardNo, BYTE Port, WORD Address, BYTE Data, WORD DataNum)	79	△
int CM100_ReceiveCmd(BYTE BoardNo, BYTE Port, BYTE *Data, WORD *DataNum)	80	△
int CM100_SendCmd(BYTE BoardNo, BYTE Port, BYTE *Data, WORD DataNum)	81	△
int CM100_InstallUserISR(BYTE BoardNo, void (*UserISR)(BYTE BoardNo, BYTE InttValue))	82	△
int CM100_RemoveUserISR(BYTE BoardNo)	83	△

Table 4.1 PISO-CM100-D/T Windows APIs List

Note: In table 3.1, the mark ○ and △ indicate the valid condition of API functions. The function marked by ○ or △ presents that this function is useful when the PISO-CM100-D/T is default CM100 firmware inside

or user-defined firmware inside respectively. If users use default firmware, all of the functions marked by ○ could be applied. However, if users design their own firmware by using firmware library (firmware library is described in section 3.4), only the functions marked by △ is useful. The functions marked with ○△ can be used with default firmware or in user-defined firmware.

In order to make the descriptions more simplified and clear, the attributes for the both the input and output parameter functions are given as **[input]** and **[output]** respectively, as shown in following table.

Keyword	Set parameter by user before calling this function?	Get the data from this parameter after calling this function?
[input]	Yes	No
[output]	No	Yes

Table 4.2 Description of API parameter Hint

4.1.1 CM100_GetDllVersion

- **Description:**

Obtain the version information of CM100.dll driver.

- **Syntax:**

WORD CM100_GetDllVersion(void)

- **Parameter:**

None

- **Return:**

DLL version information. For example: If 100(hex) is return, it means driver version is 1.00.

4.1.2 CM100_GetBoardInf

- **Description:**

Obtain the information of PISO-CM100-D/T, PISO-DNM100-D/T or PISO-CPM100-D/T, which include vender ID, device ID and interrupt number.

- **Syntax:**

```
int CM100_GetBoardInf(BYTE BoardNo, DWORD *dwVID,  
                      DWORD *dwDID, DWORD *dwSVID,  
                      DWORD *dwSDID, DWORD *dwSAuxID,  
                      DWORD *dwIrqNo)
```

- **Parameter:**

BoardNo: [input] Switch No of PISO-CM100-D/T, PISO-DNM100-D/T or PISO-CPM100-D/T DIP. The value is from 0 to 15.

*dwVID: [output] The address of a variable which is used to receive the vendor ID.

*dwDID: [output] The address of a variable used to receive device ID.

*dwSVID: [output] The address of a variable applied to receive sub-vendor ID.

*dwSDID: [output] The address of a variable applied to receive sub-device ID.

*dwSAuxID: [output] The address of a variable used to receive sub-auxiliary ID.

*dwIrqNo: [output] The address of a variable used to receive logical interrupt number.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

4.1.3 CM100_TotalBoard

- **Description:**

Obtain the total board number of PISO-CM100-D/T, PISO-DNM100- D/T, and PISO-CPM100-D/T boards installed in the PCI bus.

- **Syntax:**

Int CM100_TotalBoard(void)

- **Parameter:**

None

- **Return:**

Return the scanned total board number.

4.1.4 CM100_TotalCM100Board

- **Description:**

Obtain the total board number of PISO-CM100-D/T installed in the PCI bus.

- **Syntax:**

Int CM100_TotalCM100Board(void)

- **Parameter:**

None

- **Return:**

Return the scanned total PISO-CM100-D/T number.

4.1.5 CM100_TotalDNM100Board

- **Description:**

Obtain the total board number of PISO-DNM100-D/T installed in the PCI bus.

- **Syntax:**

Int CM100_TotalDNM100Board(void)

- **Parameter:**

None

- **Return:**

Return the scanned total PISO-DNM100-D/T number.

4.1.6 CM100_TotalCPM100Board

- **Description:**

Obtain the total board number of PISO-CPM100-D/T plugged in the PCI bus.

- **Syntax:**

Int CM100_TotalCPM100Board(void)

- **Parameter:**

None

- **Return:**

Return the scanned total PISO-CPM100-D/T number.

4.1.7 CM100_GetCM100BoardSwitchNo

- **Description:**

Obtain the DIP switch No. of PISO-CM100-D/T.

- **Syntax:**

```
Int CM100_GetCM100BoardSwitchNo(BYTE BoardCntNo,  
                                BYTE *BoardSwitchNo)
```

- **Parameter:**

BoardCntNo: [input] The number of specified PISO-CM100-D/T. For example, if the first PISO-CM100-D/T is applied, this value is 0. If the second board is applied, this value is 1.

* BoardSwitchNo: [output] The address of a variable used to get the DIP switch No. of PISO-CM100-D/T.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

4.1.8 CM100_GetDNM100BoardSwitchNo

- **Description:**

Obtain the DIP switch No. of PISO-DNM100-D/T.

- **Syntax:**

Int CM100_GetDNM100BoardSwitchNo(BYTE BoardCntNo,
BYTE *BoardSwitchNo)

- **Parameter:**

BoardCntNo: [input] The number of specified PISO-DNM100-D/T. For example, if the first PISO-DNM100-D/T is applied, this value is 0. If the second board is applied, this value is 1.

* BoardSwitchNo: [output] The address of a variable used to get the DIP switch No. of PISO-DNM100-D/T.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board number.

4.1.9 CM100_GetCPM100BoardSwitchNo

- **Description:**

Obtain the DIP switch No. of PISO-CPM100-D/T installed in the PCI bus.

- **Syntax:**

```
Int CM100_GetCPM100BoardSwitchNo(BYTE BoardCntNo,  
                                   BYTE *BoardSwitchNo)
```

- **Parameter:**

BoardCntNo: [input] The number of specified PISO-DNM100-D/T. For example, if the first PISO-DNM100-D/T is applied, this value is 0. If the second board is applied, this value is 1.

* BoardSwitchNo: [output] The address of a variable used to get the DIP switch No. of PISO-CPM100-D/T.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

4.1.10 CM100_GetCardPortNum

- **Description:**

Obtain the port numbers of PISO-CM100-D/T, PISO-DNM100-D/T, or PISO-CPM100-D/T installed in the PCI bus.

- **Syntax:**

Int CM100_GetCardPortNum(BYTE BoardNo, BYTE *bGetPortNum)

- **Parameter:**

BoardNo: [input] Switch No of PISO-CM100-D/T, PISO-DNM100-D/T or PISO-CPM100-D/T DIP. The value is from 0 to 15.

* bGetPortNum: [output] The address of a variable used to obtain the port numbers of PISO-CM100-D/T.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

4.1.11 CM100_ActiveBoard

- **Description:**

Activate PISO-CM100-D/T. It must be called once before using the other functions of PISO-CM100-D/T APIs.

- **Syntax:**

int CM100_ActiveBoard(BYTE BoardNo)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

CM100_ActiveBoardError: This board can not be activated or kernel
driver can not be found.

4.1.12 *CM100_CloseBoard*

- **Description:**

Stop and close the kernel driver and release the device resource from computer device resource. This method must be called once before exiting the user's application program.

- **Syntax:**

int CM100_CloseBoard(BYTE BoardNo)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

4.1.13 *CM100_BoardIsActive*

- **Description:**

Obtain the active status of the specific board.

- **Syntax:**

int CM100_BoardIsActive(BYTE BoardNo)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

- **Return:**

0: means the board is inactive.

1: means the board is active.

4.1.14 CM100_ AdujstDateTime

- **Description:**

Adjust date and time of PISO-CM100-D/T by using PC time.

- **Syntax:**

int CM100_AdujstDateTime(BYTE BoardNo)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_SetDateTimeFailure: Set date and time failure.

4.1.15 CM100_Reset

- **Description:**

Reset the CAN controller, SJA1000, of the PISO-CM100-D/T.

- **Syntax:**

int CM100_Reset(BYTE BoardNo, BYTE Port)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

4.1.16 CM100_Init

- **Description:**

Initiate the CAN controller.

- **Syntax:**

int CM100_Init(BYTE BoardNo, BYTE Port)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_ModeError: This board is in download mode, and can't be
changed to firmware mode.

4.1.17 CM100_HardwareReset

- **Description:**

Reset the PISO-CM100 hardware, such as CAN controller, DPRAM, 186 CPU, ..., and so forth.

- **Syntax:**

```
int CM100_HardwareReset(BYTE BoardNo, BYTE Port)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_ModeError: This board is in download mode, and can't be
changed to firmware mode.

4.1.18 CM100_Check186Mode

- **Description:**

Obtain the specified PISO-CM100-D/T if it is in download mode or in firmware mode.

- **Syntax:**

int CM100_Check186Mode(BYTE BoardNo, BYTE *Mode)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

*Mode: [output] The address of a variable used to get the PISO-CM100-D/T mode. If this value is 0, it indicates that the PISO-CM100-D/T is in download mode. If 1, it is in firmware mode. When PISO-CM100-D/T is in download mode, it can only update the firmware and the firmware will not work at the same time. Users can use CM100_Init() function to set the PISO-CM100-D/T into firmware mode.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_InitError: The PISO-CM100-D/T replies erroneously.

CM100_ModeError: This board is in download mode, and can't be changed to firmware mode.

4.1.19 CM100_Status

- **Description:**

Obtain the status of the CAN controller for the specific PISO-CM100-D/T400/200 board.

- **Syntax:**

```
int CM100_Status(BYTE BoardNo, BYTE Port, BYTE *bStatus)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

*bStatus: [output] The address of a variable is applied to get the status value of CAN controller.

Bit	NAME	VALUE	STATUS
bit 7	Bus Status	1	bus-off
		0	bus-on
bit 6	Error Status	1	error
		0	ok
bit 5	Transmit Status	1	transmit
		0	idle
bit 4	Receive Status	1	receive
		0	idle
bit 3	Transmission Complete Status	1	complete
		0	incomplete
bit 2	Transmit Buffer Status	1	release
		0	locked
bit 1	Data Overrun Status	1	overrun
		0	absent
bit 0	Receive Buffer Status	1	full/not empty
		0	empty

Table 4.3 Bit interpretation of the bStatus.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

4.1.20 CM100_AddCyclicTxMsg

- **Description:**

Add a cyclic transmission message into cm100 firmware. Afterwards, users can enable or disable this cyclic transmission messages by using CM100_EnableCyclicTxMsg() and CM100_DelectCyclicTxMsg() functions. The maximum number of the transmission messages is 5. After adding a cyclic transmission message, the handle for this message will be returned. The less value of handle indicates the higher priority of this cyclic transmission message.

- **Syntax:**

```
int CM100_AddCyclicTxMsg(BYTE BoardNo, BYTE Port, BYTE Mode,
                        DWORD MsgID, BYTE RTR,
                        BYTE DataLen, BYTE *Data,
                        DWORD TimePeriod, BYTE *Handle)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Mode: [input] 0 for 11-bit message ID, 1 for 29-bit message ID.

MsgID: [input] CAN message ID.

RTR: [input] Set remote-transmit-request is used or not. 0 is for useless,
1 is for useful.

DataLen: [input] CAN message data length. The maximum value is 8.

*Data: [input] The start address of the data buffer of a CAN message.

The maximum space of *Data is 8 bytes.

TimePeriod: [input] The time period of cyclic transmission. This
parameter is formatted by 0.1ms. The minimum value is 5.

*Handle: [output] The address of a variable is used to get the handle of a cyclic transmission. When users want to enable or disable the specified cyclic transmission, this value must be needed.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_SetCyclicMsgFailure: The cyclic transmission messages are over 5 messages or PISO-CM100-D/T replies erroneously.

4.1.21 CM100_DeleteCyclicTxMsg

- **Description:**

Remove the specified cyclic transmission message which is added by CM100_AddCyclicTxMsg() function.

- **Syntax:**

```
int CM100_DeleteCyclicTxMsg(BYTE BoardNo, BYTE Port,  
                             BYTE Handle)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Handle: [input] The handle of cyclic transmission message which is obtained by CM100_AddCyclicTxMsg() function.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_SetCyclicMsgFailure: The PISO-CM100-D/T replies erroneously.

4.1.22 CM100_EnableCyclicTxMsg

- **Description:**

Enable the cyclic transmission message which is added by CM100_AddCyclicTxMsg() function before. After enabling the specified cyclic transmission message, PISO-CM100-D/T will transmit the specified CAN message by configured time period.

- **Syntax:**

```
int CM100_EnableCyclicTxMsg(BYTE BoardNo, BYTE Port,  
                             BYTE Handle)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Handle: [input] The handle of cyclic transmission message which is obtained by CM100_AddCyclicTxMsg() function.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_SetCyclicMsgFailure: The PISO-CM100-D/T replies erroneously.

4.1.23 CM100_DisableCyclicTxMsg

- **Description:**

Disable the cyclic transmission message which is enabled by CM100_EnableCyclicTxMsg() function.

- **Syntax:**

```
int CM100_DisableCyclicTxMsg(BYTE BoardNo, BYTE Port,  
                             BYTE Handle)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Handle: [input] The handle of cyclic transmission message which is obtained by CM100_AddCyclicTxMsg() function.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_SetCyclicMsgFailure: The PISO-CM100-D/T replies erroneously.

4.1.24 CM100_OutputByte

- **Description:**

Write the data to the specified CAN controller register, SJA1000 register, of the PISO-CM100-D/T.

- **Syntax:**

```
void CM100_OutputByte(BYTE BoardNo, BYTE Port, WORD wOffset,  
                      BYTE bValue)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

wOffset: [input] The register address of SJA1000.

bValue: [input] The value written to the specified register.

- **Return:**

None

4.1.25 CM100_InputByte

- **Description:**

Read the data from the specified CAN controller register, SJA1000 register, of the PISO-CM100-D/T.

- **Syntax:**

BYTE CM100_InputByte(BYTE BoardNo, BYTE Port, WORD wOffset)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

wOffset: [input] The register address of SJA1000.

- **Return:**

The value read from the specified register.

4.1.26 **CM100_ClearSoftBuffer** <For default firmware>

- **Description:**

Clear the software buffer of the PISO-CM100-D/T. When users use these functions, CM100_SendMsg(), CM100_SendWithoutStruct(), CM100_ReceiveMsg() or CM100_ReceiveWithoutStruct(), and get the error code, CM100_SoftBufferIsFull, this function may be needed.

- **Syntax:**

int CM100_ClearSoftBuffer(BYTE BoardNo, BYTE Port)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

4.1.27 **CM100_ClearBufferStatus** <For default firmware>

- **Description:**

Clear the software buffer of the PISO-CM100-D/T. When users use these functions, CM100_SendMsg(), CM100_SendWithoutStruct(), CM100_ReceiveMsg() or CM100_ReceiveWithoutStruct(), and get the error code, CM100_SoftBufferIsFull, this function may be needed.

- **Syntax:**

int CM100_ClearBufferStatus(BYTE BoardNo, BYTE Port)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

4.1.28 CM100_ClearDataOverrun <For default firmware>

- **Description:**

Clear the data overrun status of CAN controller, SJA1000. When users use CM100_Status() to get the status value of CAN controller. If users obtain the data status is ON, this function may be needed.

- **Syntax:**

int CM100_ClearDataOverrun(BYTE BoardNo, BYTE Port)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

4.1.29 CM100_Config <For default firmware>

- **Description:**

Configure the baud, message filter of CAN controller. After calling this function, the PISO-CM100 can start to send/receive CAN messages to/from the CAN network.

- **Syntax:**

```
int CM100_Config(BYTE BoardNo, BYTE Port,  
                ConfigStruct *CanConfig)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

* CanConfig: [input] The address of a ConfigStruct structure variable used to configure the PISO-CM100-D/T. The ConfigStruct structure is defined as following:

```
typedef struct{  
    BYTE AccCode[4];  
    BYTE AccMask[4];  
    BYTE BaudRate;  
    BYTE BT0,BT1;
```

```
} ConfigStruct;
```

AccCode[4]: Acceptance code of CAN controller.

AccMask[4]: Acceptance mask of CAN controller.

The AccCode is used for deciding what kind of ID the CAN controller will accept. The AccMask is used for deciding which bit of ID will need to check with AccCode. If the bit of AccMask is set to 0, it means that the bit in the same position of ID need to be checked, and that ID bit value needs to match the bit of AccCode in the same position.

AccCode and AccMask	Bit Position	Filter Target
high byte of the high word	bit7~bit0	bit10 ~ bit3 of ID
low byte of the high word	bit7~bit5	bit2 ~ bit0 of ID
low byte of the high word	bit4	RTR
low byte of the high word	bit3~bit0	no use
high byte of the low word	bit7~bit0	bit7 ~ bit0 of 1st byte data
low byte of the low word	bit7~bit0	bit7 ~ bit0 of 2nd byte data

Table 4.4 AccCode and AccMask Definition For 11-bit ID

AccCode and AccMask	Bit Position	Filter Target
high byte of the high word	bit7~bit0	bit28~ bit21 of ID
low byte of the high word	bit7~bit0	bit20 ~ bit13 of ID
high byte of the low word	bit7~bit0	bit12 ~ bit5 of ID
low byte of the low word	bit7~bit3	bit4 ~ bit0 of ID
low byte of the low word	bit2	RTR
low byte of the low word	bit1~bit0	no use

Table 4.5 AccCode and AccMask Definition For 29-bit ID

For example (In 29 bit ID message):

	Array[0]	Array[1]	Array[2]	Array[3]	
AccCode :	00h	00h	00h	A0h	
AccMask :	FFh	FFh	FFh	1Fh	
ID bit	bit28~bit21	bit20~bit13	bit12~bit5	bit4~bit0	
ID Value :	xxxx xxxx	xxxx xxxx	xxxx xxxx	101x x	will be accepted

(Note: The mark “x” means don’t care. And the mark “h” behind the value means hex format.)

BaudRate:

Value	Description
0	User-defined baud (BT0,BT1 are needed)
1	10 K bps
2	20 K bps
3	50 K bps
4	125 K bps
5	250 K bps
6	500 K bps
7	800 K bps
8	1000 K bps

Table 4.6 Relation Between BaudRate value and Baud

BT0, BT1: User-defined baud rate (used only if BaudRate=0). For example, set BT0=0x04 and BT1=0x1C, then baud setting for the CAN controller is 100Kbps. For more detailed baud setting, please refer to manual of SJA1000 CAN controller.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_InitError: The PISO-CM100-D/T replies erroneously.

4.1.30 **CM100_ConfigWithoutStruct** <For default firmware>

- **Description:**

This function is similar with CM100_Config(). The difference is the input parameters of function. This function uses no structure parameter so that it is easy to be applied in some program environment, such as VB. Therefore, about the input parameters of this function, please refer to the CM100_Config() function for the more detailed information.

- **Syntax:**

```
int CM100_ConfigWithoutStruct(BYTE BoardNo, BYTE Port,  
                              DWORD AccCode, DWORD AccMask,  
                              BYTE BaudRate, BYTE BT0,  
                              BYTE BT1)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

AccCode: [input] Acceptance code of CAN controller.

AccMask: [input] Acceptance mask of CAN controller.

BaudRate: [input] The baud indicator of CAN controller.

BT0: [input] User-defined baud.

BT1: [input] User-defined baud.

For more information about these parameters, please refer to the section 3.2.28.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_InitError: The PISO-CM100-D/T replies erroneously.

4.1.31 **CM100_RxMsgCount** <For default firmware>

- **Description:**

Obtain the number of CAN messages available in the reception software buffer.

- **Syntax:**

int CM100_RxMsgCount(BYTE BoardNo, BYTE Port)

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

- **Return:**

The number of CAN messages in software buffer.

4.1.32 CM100_ReceiveMsg <For default firmware>

- **Description:**

Obtain the received message from software buffer. Before using this function, the CAN controller must be configured by using CM100_Config() or CM100_ConfigWithoutStruct() functions.

- **Syntax:**

```
int CM100_ReceiveMsg(BYTE BoardNo, BYTE Port,  
                    PacketStruct *CanPacket)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

*CanPacket: [output] The address of a PacketStruct structure variable used to get a CAN message. The PacketStruct structure is defined as following:

```
typedef struct packet{  
    LONGLONG MsgTimeStamps;  
    BYTE    mode;  
    DWORD id;  
    BYTE    rtr;  
    BYTE    len;  
    BYTE    data[8];  
} PacketStruct;
```

MsgTimeStamps: This parameter will record the time when PISO-CM100-D/T got a CAN message. This is formatted by 0.1 ms. The time base of this value refers to the hardware clock of PISO-CM100-D/T. When the personal computer boots up, the hardware clock starts to count.

mode: 0 for 11-bit message ID, 1 for 29-bit message ID.

id: CAN message ID.

rtr: 0 for remote-transmit-request format is not used, 1 for remote-transmit-request is used.

len: Data length of a CAN message

data[8]: data of a CAN message

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_SoftBufferIsEmpty: There is no CAN message in reception software buffer.

CM100_SoftBufferIsFull: Users can still get CAN message from the reception software buffer, but the software buffer is overflow.

CM100_TimeOut: The PISO-CM100-D/T has no response.

4.1.33 CM100_ReceiveWithoutStruct <For default firmware>

- **Description:**

Obtain a received message from software buffer. This function is similar with CM100_ReceiveMsg() function. The difference is that this function doesn't use any structure parameter. It is easy to use in some program environment, such as VB. Therefore, the input parameters of function can refer to CM100_ReceiveMsg() for more detailed information.

- **Syntax:**

```
int CM100_ReceiveWithoutStruct(BYTE BoardNo, BYTE Port,  
                                BYTE *Mode, DWORD *MsgID,  
                                BYTE *RTR, BYTE *DataLen,  
                                BYTE *Data , DWORD *UpperTime ,  
                                DWORD *LowerTime)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

*Mode: [output] The address of a variable used to get the mode of a CAN message. If value is 0, the received CAN message is with 11-bit ID. The 29-bit ID of a CAN message will have value 1.

*MsgID: [output] The address of a variable used to get the CAN message ID.

*RTR: [output] The address of a variable used to obtain the status of this CAN message. 0 for remote-transmit-request format is not used, 1 for remote- transmit-request is used.

*DataLen: [output] The address of a variable used to obtain the data length of a CAN message. The range of this value is from 0 to 8.

*Data: [output] The start address of a buffer used to get the data of a CAN message. Users need to put an 8-byte element array in this filed.

*UpperTime: [output] The address of a variable used to obtain the higher double-word of time stamp of a CAN message.

*LowerTime: [output] The address of a variable used to obtain the lower double-word of time stamp of a CAN message. The unit of UpperTime and LowerTime are 0.1ms.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_SoftBufferIsEmpty: There is no CAN message in reception software buffer.

CM100_SoftBufferIsFull: Users can still get CAN message from the reception software buffer, but the software buffer is overflow.

CM100_TimeOut: The PISO-CM100-D/T has no response.

4.1.34 CM100_SendMsg <For default firmware>

- **Description:**

Send a CAN message to software transmission buffer. When the CAN bus is idle, this CAN message will be sent to CAN network. Note that if users make some mistakes of CAN bus wiring and configuration, the CAN messages may not be transmitted successfully. In this case, the messages sent by users will be put in the transmission buffer. Users can use the API CM100_Status to check if any error is happen.

- **Syntax:**

```
int CM100_SendMsg(BYTE BoardNo, BYTE Port,  
                  PacketStruct *CanPacket)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

*CanPacket: [input] The address of a PacketStruct structure variable used to describe the sent CAN message. About the definition of PacketStruct, please refer to the description of CM100_ReceiveMsg() function.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: Port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_SoftBufferIsFull: The transmission software buffer is overflow.

4.1.35 **CM100_SendWithoutStruct** <For default firmware>

- **Description:**

Send a CAN message to software transmission buffer. When the CAN bus is idle, this CAN message will be sent to CAN network. This function is similar with CM100_SendMsg() function. The difference is that this function doesn't use any structure parameter. It is easy to use in some program environment, such as VB. Therefore, the input parameters of function can refer to CM100_SendMsg() for more detailed information. Note that if users make some mistakes of CAN bus wiring and configuration, the CAN messages may not be transmitted successfully. In this case, the messages sent by users will be put in the transmission buffer. Users can use the API CM100_Status to check if any error is happen.

- **Syntax:**

```
int CM100_SendWithoutStruct(BYTE BoardNo, BYTE Port, BYTE Mode,  
                             DWORD MsgID, BYTE RTR,  
                             BYTE DataLen, BYTE *Data)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Mode: [input] 0 for 11-bit message ID, 1 for 29-bit message ID.

MsgID: [input] CAN message ID.

RTR: [input] 0 for remote-transmit-request format is not used, 1 for remote-transmit-request is used.

DataLen: [input] Data length of a transmitted CAN message. The maximum value is 8.

*Data: [input] The start address of a buffer is used to store the transmitted data of a CAN message.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_SoftBufferIsFull: The transmission software buffer is overflow.

4.1.36 **CM100_SJA1000Config** <For user-defined firmware>

- **Description:**

Configure the message filter and baud of CAN controller, SJA1000. About the input parameters of this function, please refer to the CM100_Config() function for the more detailed information.

- **Syntax:**

```
int CM100_SJA1000Config(BYTE BoardNo, BYTE Port,  
                        DWORD AccCode, DWORD AccMask,  
                        BYTE BaudRate, BYTE BT0, BYTE BT1)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

AccCode: [input] Acceptance code of CAN controller.

AccMask: [input] Acceptance mask of CAN controller.

BT0: [input] User-defined baud.

BT1: [input] User-defined baud.

For the more information about these parameters, please refer to the section 3.2.28.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_TimeOut: The PISO-CM100-D/T has no response.

CM100_InitError: The PISO-CM100-D/T replies erroneously.

4.1.37 CM100_DPRAMInttToCM100 <For user-defined firmware>

- **Description:**

Send an interrupt signal to PISO-CM100-D/T. This interrupt signal will pass to the user-defined firmware. Therefore, users can do something for it. Be careful about that too many interrupt signals at a short time will affect the normal procedure of the user-defined firmware.

- **Syntax:**

```
int CM100_DPRAMInttToCM100(BYTE BoardNo, BYTE Port,  
                             BYTE Data)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Data: [input] Interrupt indicator. The range is from 0x00 to 0xdf. Users can define their own interrupt indicator and do some specified thing for it in user-defined firmware.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The data of input parameter is over 0xdf.

4.1.38 **CM100_DPRAMWriteByte** <For user-defined firmware>

- **Description:**

Write one byte data into the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int CM100_DPRAMWriteByte(BYTE BoardNo, BYTE Port,  
                          WORD Address, BYTE Data)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Address: [input] The specified address of DPRAM where users want to write data.

Data: [input] The byte data written to the DPRAM of PISO-CM100-D/T.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The Address of input parameter is over 6999.

4.1.39 **CM100_DPRAMWriteWord** <For user-defined firmware>

- **Description:**

Write one word data into the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int CM100_DPRAMWriteWord(BYTE BoardNo, BYTE Port,  
                           WORD Address, WORD Data)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Address: [input] The specified address of DPRAM where users want to write data.

Data: [input] The word data written to the DPRAM of PISO-CM100-D/T.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The Address of input parameter is over 6998.

4.1.40 **CM100_DPRAMWriteDword** <For user-defined firmware>

- **Description:**

Write one double-word data into the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int CM100_DPRAMWriteDword(BYTE BoardNo, BYTE Port,  
                           WORD Address, DWORD Data)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Address: [input] The specified address of DPRAM where users want to write data.

Data: [input] The double-word data written to the DPRAM of PISO-CM100-D/T.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The Address of input parameter is over 6996.

4.1.41 **CM100_DPRAMWriteMultiByte** <For user-defined firmware>

- **Description:**

Write multi-byte data into specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int CM100_DPRAMWriteMultiByte(BYTE BoardNo, BYTE Port,  
                                WORD Address, BYTE *Data,  
                                WORD DataNum)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Address: [input] The specified start address of DPRAM where users want to write data.

*Data: [input] The start address of a byte array written to the DPRAM of PISO-CM100-D/T.

DataNum: [input] The byte number of an data array written to the DPRAM of PISO-CM100-D/T.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The sum of Address and DataNum of input parameters is over 6999.

4.1.42 **CM100_DPRAMReadByte** <For user-defined firmware>

- **Description:**

Read one byte data from the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int CM100_DPRAMReadByte(BYTE BoardNo, BYTE Port,  
                        WORD Address, BYTE *Data)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Address: [input] The specified address of DPRAM where users want to read data.

*Data: [output] The address of a variable used to receive the data obtained by CM100_DPRAMReadByte() function.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The Address of input parameter is over 6999.

4.1.43 **CM100_DPRAMReadWord** <For user-defined firmware>

- **Description:**

Read one word data from the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int CM100_DPRAMReadWord(BYTE BoardNo, BYTE Port,  
                          WORD Address, WORD *Data)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Address: [input] The specified address of DPRAM where users want to read data.

*Data: [output] The address of a variable applied to receive the data obtained by CM100_DPRAMReadWord() function.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The Address of input parameter is over 6998.

4.1.44 **CM100_DPRAMReadDword** <For user-defined firmware>

- **Description:**

Read one double-word data from the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int CM100_DPRAMWriteDword(BYTE BoardNo, BYTE Port,  
                           WORD Address, DWORD *Data)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Address: [input] The specified address of DPRAM where users want to write data.

*Data: [output] The address of a variable applied to receive the data obtained by CM100_DPRAMReadDword() function.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The Address of input parameter is over 6996.

4.1.45 **CM100_DPRAMReadMultiByte** <For user-defined firmware>

- **Description:**

Read multi-byte data into the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int CM100_DPRAMReadMultiByte(BYTE BoardNo, BYTE Port,  
                              WORD Address, BYTE *Data,  
                              WORD DataNum)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Address: [input] The specified start address of DPRAM where users read to write data.

*Data: [output] The start address of a byte array applied to receive the DPRAM data.

DataNum: [input] The byte numbers which users will want to read from the DPRAM of PISO-CM100-D/T.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The sum of Address and DataNum of input parameters is over 6999.

4.1.46 **CM100_DPRAMMemset** <For user-defined firmware>

- **Description:**

Set multi-byte DPRAM data to be the specified value. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int CM100_DPRAMMemset(BYTE BoardNo, BYTE Port,  
                        WORD Address, BYTE Data,  
                        WORD DataNum)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

Address: [input] The specified start address of DPRAM where users want to write data.

Data: [input] The data written to DPRAM of PISO-CM100-D/T.

DataNum: [input] The byte numbers which users will want to write to DPRAM of PISO-CM100-D/T.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The sum of Address and DataNum of input parameters is over 6999.

4.1.47 **CM100_ReceiveCmd** <For user-defined firmware>

- **Description:**

Use this function to receive the command transmitted from the user-defined firmware. When users use DPRAMSendCmd() to send a command in the user-defined firmware, call this function to receive the command from the user-defined firmware. If users do not receive the command until another command is given from the user-defined firmware, the former one will be covered by the latter one. About DPRAMSendCmd(), please refer to 3.4.17 for more information.

- **Syntax:**

```
int CM100_ReceiveCmd(BYTE BoardNo, BYTE Port, BYTE *Data,  
                    WORD *DataNum)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

*Data: [output] The start address of a byte array applied to receive the command from DPRAM of PISO-CM100-D/T.

*DataNum: [output] The address of a variable applied to receive the command length.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_NoDpramCmd: There is no command transmitted from user-defined firmware.

CM100_DpramOverRange: The command length is over 512 bytes.

4.1.48 **CM100_SendCmd** <For user-defined firmware>

- **Description:**

Call this function to send the command to user-defined firmware. The maximum command length is 512 bytes. Afterwards, users can use DPRAMReceiveCmd() function of firmware library to get this command. About DPRAMReceiveCmd() function, please refer to section 3.4.16 for more detailed information.

- **Syntax:**

```
int CM100_SendCmd(BYTE BoardNo, BYTE Port, BYTE *Data,  
                  WORD DataNum)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

Port: [input] CAN port No. For PISO-CM100-D/T, this value is always 1.

*Data: [input] The start address of a byte array of a sent command.

DataNum: [input] The word value indicates how many bytes users will send to user-defined firmware.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_PortNumberError: The port number is not correct.

CM100_DpramOverRange: The command length is over 512 bytes.

4.1.49 **CM100_InstallUserISR** <For user-defined firmware>

- **Description:**

Using this function can allow users to apply ISR (interrupt service routine). When users put their ISR into this function, all of interrupt signals defined by users in user-defined firmware will trigger the users' ISR. Besides, the interrupt signal, CAN_COMM_CMD_FROM_CM100, defined in "cm100.h" will also pass to users' ISR when CM100.dll get a command from the user-defined firmware.

- **Syntax:**

```
int CM100_InstallUserISR(BYTE BoardNo,  
                        void (*UserISR)(BYTE BoardNo, BYTE InttValue))
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

(*UserISR)(BYTE BoardNo, BYTE InttValue)): [input] The pointer which points a function with format "void XXX(Byte BoardNo, Byte InttValue)". The XXX is the function name of users' ISR. The parameter, BoardNo, indicates the number of the board which produces an interrupt signal. The parameter, InttValue, is the interrupt indicator which may be the value CAN_COMM_CMD_FROM_CM100 or be the interrupt indicator transmitted from user-defined firmware.

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned total board numbers.

CM100_ActiveBoardError: This board is not activated.

CM100_DpramOverRange: The command length is over 512 bytes.

4.1.50 CM100_RemoveUserISR <For user-defined firmware>

- **Description:**

When users don't need the ISR function, call this function to remove users ISR.

- **Syntax:**

```
int CM100_RemoveUserISR(BYTE BoardNo)
```

- **Parameter:**

BoardNo: [input] PISO-CM100-D/T DIP switch No. (0~15).

- **Return:**

CM100_NoError: OK

CM100_DriverError: Kernel driver is not opened.

CM100_BoardNumberError: BoardNo exceeds the current scanned
total board numbers.

CM100_ActiveBoardError: This board is not activated.

4.2 Windows API Return Codes Troubleshooting

Return Code	Error ID (Error Description)	Troubleshooting
0	CM100_NoError	OK
1	CM100_DriverError	<ol style="list-style-type: none">1. Reinstall PISO-CM100-D/T driver correctly.2. Unplug the PISO-CM100-D/T, and plug it again and turn on your PC until find it in the list of hardware management of Windows.
2	CM100_ActiveBoardError	<ol style="list-style-type: none">1. Set the BoardNo parameter of function to match the DIP switch No..2. Turn off all programs which may activate this board.3. Each PISO-CM100-D/T, PISO-DNM- D/T, or PISO-CPM-D/T has unique DIP switch No..4. Reinstall PISO-CM100-D/T driver correctly.5. Unplug the PISO-CM100-D/T, and plug it again and turn on your PC until find it in the list of hardware management of Windows.
3	CM100_BoardNumberError	<ol style="list-style-type: none">1. Set the BoardNo parameter of function to match the DIP switch No..2. Each PISO-CM100-D/T, PISO-DNM- D/T, or PISO-CPM-D/T has unique DIP switch No..3. Unplug the PISO-CM100-D/T, and plug it again and turn on your PC until find it in the list of hardware management of Windows.
4	CM100_PortNumberError	<ol style="list-style-type: none">1. Set the Port parameter to 1 if users use PISO-CM100-D/T.
7	CM100_InitError	<ol style="list-style-type: none">1. Retry the function again.2. Call the function CM100_Init() and configure PISO-CM100-D/T again.
21	CM100_SoftBufferIsEmpty	<ol style="list-style-type: none">1. Wait for a while and call the function again.
22	CM100_SoftBufferIsFull	<ol style="list-style-type: none">1. Use CM100_ClearBufferStatus() to clear the status of buffer overflow.2. Reduce the bus loading of CAN network
23	CM100_TimeOut	<ol style="list-style-type: none">1. Wait for a while and call the function again.2. Call the function CM100_Init() and configure PISO-CM100-D/T again.3. Update default firmware again by using Utility if default firmware is used.4. Confirm if user-defined firmware is in PISO-CM100-D/T or not by using Utility
24	CM100_SetCyclicMsgFailure	<ol style="list-style-type: none">1. Check if users already use 5 the cyclic messages.2. Call the function CM100_Init() and configure PISO-CM100-D/T again.

Return Code	Error ID (Error Description)	Troubleshooting
25	CM100_DpramOverRange	1. Check the Address or DataNum parameters of function if each of them or the sum of them exceeds 6999.
26	CM100_NoDpramCmd	1. Wait for a while and call the function again.
27	CM100_ModeError	1. Update the default firmware again by Utility tool if it is used.
30	CM100_NoFileInside	1. Update the default firmware again by using Utility if it is used. 2. Confirm if user-defined firmware is in PISO-CM100-D/T or not by using Utility
31	CM100_DownloadFailure	1. Close Utility and try to update the firmware one minute later. 2. Call your distributor to solve this problem
32	CM100_EEPROMDamage	1. Call your distributor to solve this problem
33	CM100_NotEnoughSpace	1. The file size of the user-defined firmware is too large to put it into the PISO-CM100-D/T.
34	CM100_StillDownloading	1. Close Utility and try to update firmware one minute later. 2. Call your distributor to solve this problem
35	CM100_BoardModeError	1. Close Utility and try to update the firmware one minute later.
36	CM100_SetDateTimeFailure	1. Call your distributor to solve this problem.
X	Transmit one CAN message successfully, but can't monitor this can messages on CAN bus.	1. Use API CM100_Status to check if any error is happen. 2. Check if CAN bus line is connected with connector of PISO-CM100. 3. Check if the baud of PISO-CM100 is correct.

Table 4.7 Return Code Troubleshooting

Note: If users' problem can't be fixed after following the recommended methods. Please contact your distributor or email to service@icpdas.com to solve the problem.

5 Functions of Firmware Library

If the default firmware is used, users do not need to read this chapter. This chapter introduces all the functions provided by firmware library, 186COMM.lib. The content includes the description and list of functions of 186COMM.lib, error code description, and simple method of troubleshooting. It is helpful to build the user-defined firmware. The section 5.1 shows the list and information of all functions supported by 186COMM.lib. The section 5.2 is the basic troubleshooting when users apply the functions of 186COMM.lib and get an unexpected return code.

5.1 *Firmware Library Definitions and Descriptions*

When users want to design their own firmware, the functions of firmware library are needed. In order to reduce the development cycle, the firmware library, 186COMM.lib, provides 4 callback functions. If users want to do some initial job, put the program into UserInitFunc() callback function. Users' normal procedure can be put in UserLoopFunc(). The firmware library will execute this callback function as soon as possible. If users would like to process some interrupt signal from DPRAM or CAN controller, use callback functions, UserDPRAMIrqFunc() and UserCANIrqFunc(), to do that. These 4 callback functions must be applied once in users' .c file. The architecture is show as figure 5.1.

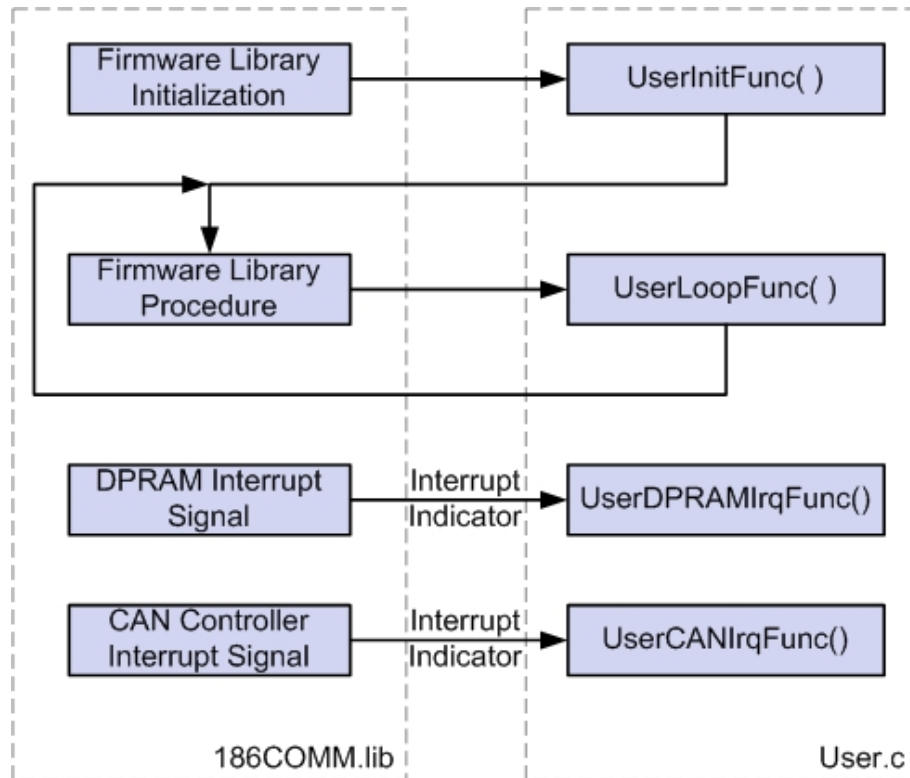


Figure 5.1 Firmware Library Operation Architecture

Besides, 186COMM.lib also supports some functions for handling the hardware of PISO-CM100-D/T, such as DPRAM access functions, EEPROM access functions, NVRAM access functions, LED control functions, real time clock access function, timer functions, debug functions, and CAN bus access functions. Users can use Borland C/C++ or Turbo C/C++ to compile user-defined firmware. By the way, the Turbo C++ 1.01 or Turbo C 2.0 can be free downloaded in the website <http://dn.codegear.com/museum>. All the functions are listed in the table 5.1 and detailed information for every function is presented in the following sub-section.

Function definition	Page
void L1Off(void)	90
void L1On(void)	90
void L2Off(void)	91
void L2On(void)	91
void DPRAMInttToHost(char InttValue)	92
void UserDPRAMIrqFunc(unsigned char INTT)	93
int DPRAMWriteByte(unsigned int Address, unsigned char Data)	94

Function definition	Page
int DPRAMWriteWord(unsigned int Address, unsigned int Data)	95
int DPRAMWriteDword(unsigned int Address, unsigned long Data)	96
int DPRAMWriteMultiByte(unsigned int Address, char *Data, unsigned int DataNum)	97
int DPRAMReadByte(unsigned int Address, unsigned char *Data)	98
int DPRAMReadWord(unsigned int Address, unsigned int *Data)	99
int DPRAMReadDword(unsigned int Address, unsigned long *Data)	100
int DPRAMReadMultiByte(unsigned int Address, char *Data, unsigned int DataNum)	101
int DPRAMMemset(unsigned int Address, char data, unsigned int DataNum)	102
int DPRAMReceiveCmd(char *Data, unsigned int *DataNum)	103
int DPRAMSendCmd(char *Data, unsigned int DataNum)	104
int DebugPrint(const char *fmt,...)	105
int GetKbhit(void)	106
int Print(const char *fmt, ...)	107
void GetTime(int *hour, int *minute, int *sec)	108
int SetTime(int hour, int minute, int sec)	109
void GetDate(int *year, int *month, int *day)	110
int SetDate(int year, int month, int day)	111
int GetWeekDay(void)	112
int ReadNVRAM(int Address)	113
int WriteNVRAM(int Address, int data)	114
unsigned long GetTimeTicks100us(void)	115
long GetTimeTicks(void)	116
void DelayMs(unsigned int DelayTime_ms)	117
void CM100_InstallUserTimer(void (*Fun)(void))	118
void T_StopWatchStart(STOPWATCH *sw)	119
unsigned long T_StopWatchGetTime(STOPWATCH *sw)	119
void T_StopWatchPause(STOPWATCH *sw)	119
void T_StopWatchContinue(STOPWATCH *sw)	119
void T_CountDownTimerStart(COUNTDOWNTIMER *cdt, unsigned long timems)	121
void T_CountDownTimerPause(COUNTDOWNTIMER *cdt)	121
void T_CountDownTimerContinue(COUNTDOWNTIMER *cdt)	121
int T_CountDownTimerIsTimeUp(COUNTDOWNTIMER *cdt)	121
unsigned long T_CountDownTimerGetTimeLeft(COUNTDOWNTIMER *cdt)	121
int CM100_EEPROMReadByte(unsigned int Block, unsigned int Address, unsigned char *Data)	123
int CM100_EEPROMReadMultiByte(unsigned int Block, unsigned int Address, char *Data, unsigned int DataNum)	124

Function definition	Page
int CM100_EEPROMWriteByte(unsigned int Block, unsigned int Address, unsigned char Data)	125
int CM100_EEPROMWriteMultiByte(unsigned int Block, unsigned int Address, char *Data, unsigned int DataNum)	126
void UserCANIrqFunc(unsigned char INTT)	127
void SJA1000HardwareReset(void)	128
int SetCANBaud(unsigned long Baud, char BT0, char BT1)	129
void GetCANBaud(unsigned long *Baud, char *BT0, char *BT1)	130
int SetCANMask(long AccCode, long AccMask)	131
void GetCANMask(long *AccCode, long *AccMask)	133
int CANConfig(unsigned long Baud, char BT0, char BT1, long AccMask, long AccCode)	134
void EnableSJA1000(void)	135
void DisableSJA1000(void)	135
int GetCANStatus(void)	136
void ClearDataOverrunStatus(void)	137
int SendCANMsg(char Mode, unsigned long MsgID, char RTR, char DataLen, char *Data)	138
void ClearTxSoftBuffer(void)	139
int GetCANMsg(char *Mode, unsigned long *MsgID, char *RTR, char *DataLen, char *Data, unsigned long *UpperTime, unsigned long *LowerTime)	140
void ClearRxSoftBuffer(void)	142
int RxMsgCount(void)	142
int AddCyclicTxMsg(char Mode, unsigned long MsgID, char RTR, char DataLen, char *Data, unsigned long TimePeriod, unsigned char *Handle)	143
int DeleteCyclicTxMsg(unsigned char Handle)	144
int EnableCyclicTxMsg(unsigned char Handle)	145
int DisableCyclicTxMsg(unsigned char Handle)	146
void ResetCyclicTxBuf(void)	146
void SystemHardwareReset(void)	147
void SystemInit(void)	147
int GetLibVer(void)	148
void RefreshWDT(void)	148
void UserInitFunc(void)	149
void UserLoopFunc(void)	150

Table 5.1 Functions List of Firmware Library For User-defined Firmware

5.1.1 L1Off

- **Description:**

Turn off the red LED of PISO-CM100-D/T.

- **Syntax:**

void L1Off(void)

- **Parameter:**

None

- **Return:**

None

5.1.2 L1On

- **Description:**

Turn on the red LED of PISO-CM100-D/T.

- **Syntax:**

void L1On(void)

- **Parameter:**

None

- **Return:**

None

5.1.3 L2Off

- **Description:**

Turn off the green LED of PISO-CM100-D/T.

- **Syntax:**

void L2Off(void)

- **Parameter:**

None

- **Return:**

None

5.1.4 L2On

- **Description:**

Turn on the green LED of PISO-CM100-D/T.

- **Syntax:**

void L1Off(void)

- **Parameter:**

None

- **Return:**

None

5.1.5 *DPRAMInttToHost*

- **Description:**

Call this function to signal the users' Windows applications an interrupt. When users' applications receive the interrupt signal from the user-defined firmware, check the value of interrupt indicator to know the meaning of this interrupt. Therefore, the user-defined firmware can communicate with the Windows applications by the definitions of interrupt indicators. Because of the interrupt mechanism, too many calls of this function will increase PC CPU loading and disturb the normal procedure of users' Windows applications.

- **Syntax:**

`void DPRAMInttToHost(char InttValue)`

- **Parameter:**

InttValue: [input] The interrupt indicator sent to users' Windows application. The range is from 0x00 ~ 0xdf.

- **Return:**

None

5.1.6 **UserDPRAMIrqFunc** *<must be called once >*

- **Description:**

This is a callback function, and must be call once in user-defined firmware. When firmware library receives an interrupt signal from users' Windows applications, it will pass the interrupt indicator from users' Windows applications to this function. Users can have some proper procedures in this function to process each interrupt indicator. It is not allowed to put an infinite loop in to this function, and users must keep the program of this function as short as possible.

- **Syntax:**

void UserDPRAMIrqFunc(unsigned char INTT)

- **Parameter:**

INTT: [input] The interrupt indicator from users' Windows application.

- **Return:**

None

5.1.7 *DPRAMWriteByte*

- **Description:**

Write one byte data into the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

int DPRAMWriteByte(unsigned int Address, unsigned char Data)

- **Parameter:**

Address: [input] The specified address of DPRAM where users want to write data.

Data: [input] The byte data written to the DPRAM of PISO-CM100-D/T.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The Address of input parameter is over 6999.

5.1.8 *DPRAMWriteWord*

- **Description:**

Write one word data into the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

int DPRAMWriteWord(unsigned int Address, unsigned int Data)

- **Parameter:**

Address: [input] The specified address of DPRAM where users want to write data.

Data: [input] The word data written to the DPRAM of PISO-CM100-D/T.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The Address of input parameter is over 6998.

5.1.9 *DPRAMWriteDword*

- **Description:**

Write one double-word data into the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

int DPRAMWriteDword(unsigned int Address, unsigned long Data)

- **Parameter:**

Address: [input] The specified address of DPRAM where users want to write data.

Data: [input] The double-word data written to the DPRAM of PISO-CM100-D/T.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The Address of input parameter is over 6996.

5.1.10 *DPRAMWriteMultiByte*

- **Description:**

Write multi-byte data into the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int DPRAMWriteMultiByte(unsigned int Address, char *Data,  
                        unsigned int DataNum)
```

- **Parameter:**

Address: [input] The specified start address of DPRAM where users want to write data.

*Data: [input] The start address of a byte array written to the DPRAM of PISO-CM100-D/T.

DataNum: [input] The byte numbers of an data array written to the DPRAM of PISO-CM100-D/T.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The sum of Address and DataNum of input parameters is over 6999.

5.1.11 *DPRAMReadByte*

- **Description:**

Read one byte data from specified the address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int DPRAMReadByte(unsigned int Address, unsigned char *Data)
```

- **Parameter:**

Address: [input] The specified address of DPRAM where users want to read data.

*Data: [output] The address of a variable used to receive the data obtained by DPRAMReadByte() function.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The Address of input parameter is over 6999.

5.1.12 *DPRAMReadWord*

- **Description:**

Read one word data from the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int DPRAMReadWord(unsigned int Address, unsigned int *Data)
```

- **Parameter:**

Address: [input] The specified address of DPRAM where users want to read data.

*Data: [output] The address of a variable applied to receive the data obtained by DPRAMReadWord() function.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The Address of input parameter is over 6998.

5.1.13 *DPRAMReadDword*

- **Description:**

Read one double-word data from the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

int DPRAMReadDword(unsigned int Address, unsigned long *Data)

- **Parameter:**

Address: [input] The specified address of DPRAM where users want to read data.

*Data: [output] The address of a variable applied to receive the data obtained by DPRAMReadDword() function.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The Address of input parameter is over 6996.

5.1.14 *DPRAMReadMultiByte*

- **Description:**

Write the multi-byte data into the specified address of DPRAM of PISO-CM100-D/T. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int DPRAMReadMultiByte(unsigned int Address, char *Data,  
                        unsigned int DataNum)
```

- **Parameter:**

Address: [input] The specified start address of DPRAM where users want to read data.

*Data: [output] The start address of a byte array applied to receive the data from DPRAM of PISO-CM100-D/T.

DataNum: [input] The byte numbers which users will want to read from the DPRAM of PISO-CM100-D/T.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The sum of Address and DataNum of input parameters is over 6999.

5.1.15 *DPRAMMemset*

- **Description:**

Set the multi-byte DPRAM data to be the specified value. The DPRAM space which can be applied is from address 0 to 6999.

- **Syntax:**

```
int DPRAMMemset(unsigned int Address, char data,  
                unsigned int DataNum)
```

- **Parameter:**

Address: [input] The specified start address of DPRAM where users want to write data.

Data: [input] The data written to DPRAM of PISO-CM100-D/T.

DataNum: [input] The byte numbers which users will want to write to DPRAM of PISO-CM100-D/T.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The sum of Address and DataNum of input parameters is over 6999.

5.1.16 *DPRAMReceiveCmd*

- **Description:**

Use this function to receive the command transmitted from the windows applications. When users use CM100_SendCmd() to a send command in Windows application, call this function to receive the command which comes from users' Windows application. If users do not receive the command until another command is given from users Windows application, the former one will be covered by the latter one. About CM100_SendCmd(), please refer to 3.2.47 for more information.

- **Syntax:**

int DPRAMReceiveCmd(char *Data, unsigned int *DataNum)

- **Parameter:**

*Data: [output] The start address of a byte array is applied to receive the command from DPRAM of PISO-CM100-D/T.

*DataNum: [output] The address of a variable is applied to receive the command length.

- **Return:**

_NO_ERR: OK

_NO_DPRAM_CMD: There is no command transmitted from user-defined firmware.

_DPRAM_OVER_RANGE: The command length is over 512 bytes.

5.1.17 *DPRAMSendCmd*

- **Description:**

Call this function to send the command to the Windows applications. The maximum command length is 512 bytes. Afterwards, users can use CM100_ReceiveCmd() function of Windows library to get this command. About CM100_ReceiveCmd() function, please refer to section 3.2.46 for more detailed information. The maximum command length can't exceed to 512 bytes.

- **Syntax:**

```
int DPRAMSendCmd(char *Data, unsigned int DataNum)
```

- **Parameter:**

*Data: [input] The start address of a byte array of a sent command.

DataNum: [input] The word value indicates how many bytes users will send to the user-defined firmware.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The command length is over 512 bytes.

5.1.18 **DebugPrint** <assist with CM100_DEBUG_MONITOR.EXE>

- **Description:**

This function is used for debugging of the user-defined firmware. Call this function to send debug the messages from user-defined firmware to CM100_DEBUG_MONITOR.exe Windows program. The use method of this function is similar with the standard C function printf(). When users use this function, execute CM100_DEBUG_MONITOR program and active PISO-CM100-D/T board to see the debug information. If the PISO-CM100-D/T board has been activated by other Windows programs, users don't need to activate the PISO-CM100-D/T again in CM100_DEBUG_MONITOR. For the more detailed information about CM100_DEBUG_MONITOR, please refer to section 6.3. The maximum string length can't exceed 100 bytes.

- **Syntax:**

int DebugPrint(const char *fmt,...)

- **Parameter:**

* fmt: [input] The string of debug information. The maximum length of *fmt string is 100 bytes. Please refer to standard C function printf() to know how to use this parameters. If users need new-line function, add "\r\n" in the end of the string of debug information.

- **Return:**

_NO_ERR: OK

_DPRAM_OVER_RANGE: The string of debug information length is over 100 bytes.

5.1.19 **GetKbhit** <assist with debug cable and 7188xw.exe>

- **Description:**

This function is used for debugging of the user-defined firmware. Call this function to get a character keyed from keyboard. GetKbhit() function is similar with standard C function GetKbhit(). When users connect the debug port of the PISO-CM100-D/T with available the RS-232 COM port of PC via the debug cable shown in section 2.2 and execute 7188xw.exe Windows program, a character keyed from keyboard will be caught by this function.

- **Syntax:**

int GetKbhit(void)

- **Parameter:**

None

- **Return:**

The return code is the received character from keyboard input when 7188xw.exe is executed and focused.

5.1.20 **Print** <assist with debug cable and 7188xw.exe>

- **Description:**

This function is used for debugging of the user-defined firmware. Call this function to send debug information to 7188xw.exe Windows program. Print() function is similar with standard C function printf(). When users connect the debug port of PISO-CM100-D/T with the available RS-232 COM port of PC via the debug cable shown in section 2.2 and execute 7188xw.exe Windows program, the debug information sent by using this function will be put to the window of 7188xe.wxe.

- **Syntax:**

int Print(const char *fmt, ...)

- **Parameter:**

* fmt: [input] The data format of keyboard input. Please refer to standard C function printf() to know how to use this parameters.

- **Return:**

If it is successful, the return code is a non-zero value except the value of EOF (defined by standard C/C++ language).

5.1.21 *GetTime*

- **Description:**

Use this function to get the current time from real time clock.

- **Syntax:**

```
void GetTime(int *hour, int *minute, int *sec)
```

- **Parameter:**

*hour: [output] The address of a variable used to receive the hour value of current time.

*minute: [output] The address of a variable used to receive the minute value of current time.

*sec: [output] The address of a variable used to receive the second value of current time.

- **Return:**

None.

5.1.22 *SetTime*

- **Description:**

Use this function to modify the time of real time clock.

- **Syntax:**

int SetTime(int hour, int minute, int sec)

- **Parameter:**

hour: [input] The hour value set to real time clock.

minute: [input] The minute value set to real time clock.

sec: [input] The second value set to real time clock.

- **Return:**

_NO_ERR: OK

_SET_TIME_ERROR: The input value of hour, minute or sec is invalid.

5.1.23 *GetDate*

- **Description:**

Use this function to get the current date from real time clock.

- **Syntax:**

```
void GetDate(int *year, int *month, int *day)
```

- **Parameter:**

*year: [output] The address of a variable used to receive the year value of current date.

*month: [output] The address of a variable used to receive the month value of current date.

*day: [output] The address of a variable used to receive the day value of current date.

- **Return:**

None.

5.1.24 *SetDate*

- **Description:**

Use this function to modify the date of real time clock.

- **Syntax:**

int SetDate(int year, int month, int day)

- **Parameter:**

year: [input] The year value set to real time clock.

month: [input] The month value set to real time clock.

day: [input] The day value set to real time clock.

- **Return:**

_NO_ERR: OK

_SET_DATE_ERROR: The input value of year, month or day is invalid.

5.1.25 *GetWeekDay*

- **Description:**

Use this function to obtain what day is today.

- **Syntax:**

int GetWeekDay(void)

- **Parameter:**

None.

- **Return:**

Return Code	Meaning
0	Sunday
1	Monday
2	Tuesday
3	Wednesday
4	Thursday
5	Friday
6	Saturday

Table 5.2 Relation Between Return Code and Day of Week

5.1.26 *ReadNVRAM*

- **Description:**

Use this function to get one-byte data of NVRAM.

- **Syntax:**

int ReadNVRAM(int Address)

- **Parameter:**

Address: [input] The NVRAM address where users will read the data.

The range of this parameter is from 0 to 30.

- **Return:**

_ACCESS_NVRAM_FAILE: The address of NVRAM is invalid.

Others: The value obtained from NVRAM. The range of return value is from 0 to 255.

5.1.27 WriteNVRAM

- **Description:**

Use this function to write one-byte data to specified address of NVRAM. If system has no power, the data stored in NVRAM will not disappear.

- **Syntax:**

int WriteNVRAM(int Address, int data)

- **Parameter:**

Address: [input] The NVRAM address where users will write the data.

The range of this parameter is from 0 to 30.

data: [input] The data written to NVRAM. The range of this parameter is from 0 to 255. If value is over 255, only low byte of data will be written to NVRAM.

- **Return:**

_NO_ERR: OK.

_ACCESS_NVRAM_FAILE: The address of NVRAM is invalid.

5.1.28 *GetTimeTicks100us*

- **Description:**

Read PISO-CM100-D/T time ticks by using this function. When the firmware starts, PISO-CM100-D/T time ticks are counted. Reset the firmware will clean the accumulated counters of this value. If the accumulated counters are over the range of an unsigned long value, the counters are also reset to 0.

- **Syntax:**

unsigned long GetTimeTicks100us(void)

- **Parameter:**

None.

- **Return:**

The time ticks numbers when firmware started. The unit is 0.1 ms.

5.1.29 *GetTimeTicks*

- **Description:**

Call this function to read PISO-CM100-D/T time ticks. When PISO-CM100-D/T has power, the time ticks are counted. This function can't be called in interrupt service routine. Reset the operation system of PISO-CM100-D/T will clean the accumulated counters of this value. If the accumulated counters are over the range of an unsigned long value, the counters are also reset to 0.

- **Syntax:**

long GetTimeTicks(void)

- **Parameter:**

None

- **Return:**

The time ticks numbers. The unit is 1 ms.

5.1.30 DelayMs

- **Description:**

Use this function to pending the procedure of user-defined firmware. Because of watch dog mechanism, users can't delay for a long time. The PISO-CM100-D/T watch dog timer is set to 800 ms. It is recommend that if users want to delay the procedure of user-defined firmware more than 500 ms. The RefreshWDT() function must be applied to avoid the watch dog timeout. This function is not allowed to put into interrupt service routine. If users want to use delay functions in interrupt service routine, it is strongly recommended to put this part of the codes of interrupt service routine into UserLoopFunc().

- **Syntax:**

void DelayMs(unsigned int DelayTime_ms)

- **Parameter:**

DelayTime_ms: [input] The delay time of procedure. The unit is 1 ms.

- **Return:**

None

5.1.31 CM100_InstallUserTimer

- **Description:**

This function can allow users to use timer interrupt. When users put their timer interrupt service routine in this function, this interrupt service routine will be executed every millisecond. Be careful that too much program in the interrupt service routine will disturb the normal procedure of user-defined firmware.

- **Syntax:**

void CM100_InstallUserTimer(void (*Fun)(void))

- **Parameter:**

(*Fun)(void): [input] The pointer which points a function with format “void XXX(void)”. The XXX is the name of a function.

- **Return:**

None

5.1.32 *T_StopWatchXXX series functions*

- **Description:**

Call this function to use a stopwatch. There are 4 functions for stopwatch operation. When users want to start a stopwatch, `T_StopWatchStart()` must be applied. Then, users can use `T_StopWatchGetTime()` to obtain the current time counts of this stopwatch. If users need to disable the time counter, use `T_StopWatchPause()` to achieve this purpose. Call `T_StopWatchContinue()` to enable this timer counter again. If users want to use more than one stopwatch, just input the different variable of structure `STOPWATCH` into these 4 functions. One structure variable will be mapped to one stopwatch. The time unit of these 4 functions and the members of `STOPWATCH` structure are millisecond.

- **Syntax:**

```
void T_StopWatchStart(STOPWATCH *sw)
```

```
unsigned long T_StopWatchGetTime(STOPWATCH *sw)
```

```
void T_StopWatchPause(STOPWATCH *sw)
```

```
void T_StopWatchContinue(STOPWATCH *sw)
```

- **Parameter:**

`*sw`: [output] The address of a `STOPWATCH` structure variable applied to describe the stopwatch. The member of `STOPWATCH` structure is shown as following:

```
typedef struct {  
    unsigned long ulStart;  
    unsigned long ulPauseTime;  
    unsigned int uMode;  
}STOPWATCH;
```

Parameter ulStart obtains the start time of stopwatch. Parameter ulPauseTime will return the last pause time of stopwatch. Parameter uMode returns the status of the stopwatch. If uMode is 0, it means that the stopwatch pauses. If uMode is 1, the stopwatch is running.

- **Return:**

The return code of T_StopWatchGetTime() is the current time counts after the stopwatch started.

5.1.33 *T_CountDownTimerXXX series functions*

- **Description:**

Call this function to use a countdown timer. There are 5 functions for countdown timer operation. When users want to start a countdown timer, T_CountDownTimerStart() must be applied. Then, If users need to disable the countdown timer, use T_CountDownTimerPause() to achieve this purpose. Call T_CountDownTimerContinue() to enable this countdown timer again. Users can use T_CountDownTimerIsTimeUp() to check if the countdown timer is timeout or not. Or, use T_CountDownTimerGetTimeLeft() to obtain the rest time of countdown timer. If users want to use more than one countdown timer, just input the different variable of structure COUNTDOWNTIMER into these 5 functions. One structure variable will be mapped to one countdown timer. The time unit of these 5 functions and the members of COUNTDOWNTIMER structure are millisecond.

- **Syntax:**

```
void T_CountDownTimerStart(COUNTDOWNTIMER *cdt,
                           unsigned long timems)
void T_CountDownTimerPause(COUNTDOWNTIMER *cdt)
void T_CountDownTimerContinue(COUNTDOWNTIMER *cdt)
int T_CountDownTimerIsTimeUp(COUNTDOWNTIMER *cdt)
unsigned long T_CountDownTimerGetTimeLeft(
                           COUNTDOWNTIMER *cdt)
```

- **Parameter:**

timems: [input] The time interval which indicates that how much time the countdown timer will countdown.

*cdt: [output] The address of a COUNTDOWNTIMER structure variable used to describe the countdown timer. The member of COUNTDOWNTIMER structure is shown as following:

```
typedef struct {
    unsigned long ulTime;
    unsigned long ulStartTime;
    unsigned long ulPauseTime;
```

```
        unsigned int uMode;  
    } COUNTDOWNTIMER;
```

Using parameter ulTime will get time interval of countdown timer. Parameter ulStartTime returns the start time of countdown timer. Parameter ulPauseTime can obtain the last pause time of countdown timer. Parameter uMode returns the status of the countdown timer. If uMode is 0, it means that the countdown timer pauses. If uMode is 1, the countdown timer is running.

- **Return:**

The return code of T_CountDownTimerIsTimeUp() is _NO_ERR or _COUNT_DOWN_TIMER_TIME_UP. If the countdown timer is timeout, the return code is _COUNT_DOWN_TIMER_TIME_UP. If not, the return code is _NO_ERR. The return code of T_CountDownTimerGetTimeLeft() is the rest time of the countdown timer.

5.1.34 CM100_EEPROMReadByte

- **Description:**

Use this function to read the data of the specified address of EEPROM.

- **Syntax:**

```
int CM100_EEPROMReadByte(unsigned int Block,  
                           unsigned int Address,  
                           unsigned char *Data)
```

- **Parameter:**

Block: [input] The EEPROM block No.. The range is from 0 to 6.

Address: [input] The EEPROM address where users will read the data.

Each block has 256 bytes. Therefore, the range of this parameter is from 0 to 255.

*data: [output] The address of a variable used to obtain the data of specified address of EEPROM

- **Return:**

_NO_ERR: OK.

_EEPROM_OVER_RANGE: The block No. is over 6, or the address is over 256.

5.1.35 CM100_EEPROMReadMultiByte

- **Description:**

Use this function to read some data from EEPROM.

- **Syntax:**

```
int CM100_EEPROMReadMultiByte(unsigned int Block,  
                                unsigned int Address,  
                                char *Data,  
                                unsigned int DataNum)
```

- **Parameter:**

Block: [input] The EEPROM block No.. The range is from 0 to 6.

Address: [input] The start EEPROM address where users will write the data. Each block has 256 bytes. Therefore, the range of this parameter is from 0 to 255.

*data: [output] The start address of a byte array used to receive the data from EEPROM

DataNum: [input] The parameter indicates that how many data users want to obtain.

- **Return:**

_NO_ERR: OK.

_EEPROM_OVER_RANGE: The block No. is over 6, or the address is over 256. Or the specified range of reading data is over the block 6 and address 255.

5.1.36 CM100_EEPROMWriteByte

- **Description:**

Use this function to write the data to specified address of EEPROM. If system has no power, the data stored in EEPROM will not disappear.

- **Syntax:**

```
int CM100_EEPROMWriteByte(unsigned int Block,  
                           unsigned int Address,  
                           unsigned char Data)
```

- **Parameter:**

Block: [input] The EEPROM block No.. The range is from 0 to 6.

Address: [input] The EEPROM address where users will write the data.

Each block has 256 bytes. Therefore, the range of this parameter is from 0 to 255.

data: [input] The data written to EEPROM

- **Return:**

_NO_ERR: OK.

_EEPROM_ACCESS_ERROR: Can't write data to specified EEPROM address. The EEPROM may be damaged.

_EEPROM_OVER_RANGE: The block No. is over 6, or the address is over 256.

5.1.37 CM100_EEPROMWriteMultiByte

- **Description:**

Use this function to write some data to specified address of EEPROM. If system has no power, the data stored in EEPROM will not disappear.

- **Syntax:**

```
int CM100_EEPROMWriteMultiByte(unsigned int Block,  
                                unsigned int Address,  
                                char *Data,  
                                unsigned int DataNum)
```

- **Parameter:**

Block: [input] The EEPROM block No.. The range is from 0 to 6.

Address: [input] The EEPROM address where users will write the data.

Each block has 256 bytes. Therefore, the range of this parameter is from 0 to 255.

*data: [output] The start address of a byte array used to store the data written to EEPROM.

DataNum: [input] The parameter indicates that how many data users want to write.

- **Return:**

_NO_ERR: OK.

_EEPROM_ACCESS_ERROR: Can't write data to specified EEPROM address. The EEPROM may be damaged.

_EEPROM_OVER_RANGE: The block No. is over 6, or the address is over 256. Or the specified range of writing data is over the block 6 and address 255.

5.1.38 UserCANIrqFunc <must be called once>

- **Description:**

This is a callback function, and must be call once in user-defined firmware. When the firmware library receives an interrupt signal from CAN controller, this function will pass the interrupt indicator of CAN controller. The interrupt indicator shows what kinds of CAN controller interrupt are active. Therefore, users only need to design their interrupt routine according to deal with the different interrupt indicators. It is not allowed to put an infinite loop in to this function, and users must keep the program of this function as short as possible.

- **Syntax:**

```
void UserCANIrqFunc(unsigned char INTT)
```

- **Parameter:**

INTT: [input] The interrupt indicator from CAN controller. The meanings of indicators are shown as following.

Indicator (Hex)	Meaning
0x01	Receive a message successfully
0x02	Transmit a message successfully
0x04	Error warring
0x08	Data Overrun
0x10	CAN controller wake-up
0x20	Bus Passive
0x40	Arbitration Lost
0x80	Bus Error

Table 5.3 CAN Interrupt Indicator Description

- **Return:**

None

5.1.39 SJA1000HardwareReset

- **Description:**

Reset the CAN controller by reset the pin of SJA1000. After calling this function, users must configure the baud and message mask of CAN controller. Then, use EnableSJA1000() to activate the SJA1000 to send and receive CAN messages.

- **Syntax:**

```
void SJA1000HardwareReset(void)
```

- **Parameter:**

None

- **Return:**

None

5.1.40 SetCANBaud

- **Description:**

Set the CAN baud of CAN controller.

- **Syntax:**

int SetCANBaud(unsigned long Baud, char BT0, char BT1)

- **Parameter:**

Baud: [input] The baud of CAN controller. There are 12 kinds of supported baud. They are 5K, 10K, 20K, 25K, 50K, 100K, 125K, 200K, 250K, 500K, 800K, 1M bps. If these bauds can not satisfy, set this parameter 0 and define the BT0 and BT1 of SJA1000 by users.

BT0: [input] User-defined baud.

BT1: [input] User-defined baud. For the more information about how to use BT0 and BT1, please refer to the data sheet of SJA1000.

- **Return:**

_NO_ERR: OK.

_CAN_CHIP_SOFT_RESET_ERR: SJA1000 can't be reset by software.
The CAN controller may be damaged.

5.1.41 *GetCANBaud*

- **Description:**

Get the current CAN baud of CAN controller.

- **Syntax:**

void GetCANBaud(unsigned long *Baud, char *BT0, char *BT1)

- **Parameter:**

*Baud: [output] The address of a variable used to obtain the baud of CAN controller. If this parameter is 0, the BT0 and BT1 are useful.

*BT0: [output] The address of a variable used to get the BT0 value obtained from SJA1000.

*BT1: [output] The address of a variable used to get the BT1 value obtained from SJA1000. For more information about how to use BT0 and BT1, please refer to the data sheet of SJA1000.

- **Return:**

None

5.1.42 SetCANMask

- **Description:**

Set the message mask of CAN controller.

- **Syntax:**

```
int SetCANMask(long AccCode, long AccMask)
```

- **Parameter:**

AccCode: [input] Acceptance code of CAN controller

AccMask: [input] Acceptance mask of CAN controller.

The AccCode is used for deciding what kind of ID the CAN controller will accept. The AccMask is used for deciding which bit of ID will need to check with AccCode. If the bit of AccMask is set to 0, it means that the bit in the same position of ID need to be checked, and that ID bit value needs to match the bit of AccCode in the same position.

AccCode and AccMask	Bit Position	Filter Target
high byte of the high word	bit7~bit0	bit10 ~ bit3 of ID
low byte of the high word	bit7~bit5	bit2 ~ bit0 of ID
low byte of the high word	bit4	RTR
low byte of the high word	bit3~bit0	no use
high byte of the low word	bit7~bit0	bit7 ~ bit0 of 1st byte data
low byte of the low word	bit7~bit0	bit7 ~ bit0 of 2nd byte data

Table 5.3 AccCode and AccMask Definition For 11-bit ID

AccCode and AccMask	Bit Position	Filter Target
high byte of the high word	bit7~bit0	bit28~ bit21 of ID
low byte of the high word	bit7~bit0	bit20 ~ bit13 of ID
high byte of the low word	bit7~bit0	bit12 ~ bit5 of ID
low byte of the low word	bit7~bit3	bit4 ~ bit0 of ID
low byte of the low word	bit2	RTR
low byte of the low word	bit1~bit0	no use

Table 5.4 AccCode and AccMask Definition For 29-bit ID

For example (In 29 bit ID message):

AccCode : 00h 00h 00h A0h

AccMask : FFh FFh FFh 1Fh

ID bit bit28~bit21 bit20~bit13 bit12~bit5 bit4~bit0

ID Value : xxxx xxxx xxxx xxxx 101x x will be accepted

(Note: The mark “x” means don’t care. And the mark “h” behind the value means hex format.)

- **Return:**

_NO_ERR: OK.

_CAN_CHIP_SOFT_RESET_ERR: SJA1000 can’t be reset by software.
The CAN controller may be damaged.

5.1.43 *GetCANMask*

- **Description:**

Get the current message mask status of CAN controller.

- **Syntax:**

```
void GetCANMask(long *AccCode, long *AccMask)
```

- **Parameter:**

- * AccCode: [output] The address of a variable used to obtain the acceptance code of SJA1000.

- * AccMask: [output] The address of a variable used to obtain the acceptance mask of SJA1000.

- **Return:**

None

5.1.44 CANConfig

- **Description:**

Configure the baud, message filter of CAN controller. After calling this function, users need to call EnableSJA1000() to active CAN controller, SJA1000.

- **Syntax:**

```
int CANConfig(unsigned long Baud, char BT0, char BT1, long AccMask,  
              long AccCode)
```

- **Parameter:**

Baud: [input] The baud of CAN controller.

BT0: [input] User-defined baud.

BT1: [input] User-defined baud.

AccCode: [input] Acceptance code of CAN controller.

AccMask: [input] Acceptance mask of CAN controller.

For the more information about these parameters, please refer to the section 3.4.49 and 3.4.51.

- **Return:**

_NO_ERR: OK.

_CAN_CHIP_SOFT_RESET_ERR: SJA1000 can't be reset by software.

The CAN controller may be damaged.

5.1.45 *EnableSJA1000*

- **Description:**

Use this function to activate SJA1000. Afterwards, users can send/receive CAN messages by other functions.

- **Syntax:**

void EnableSJA1000(void)

- **Parameter:**

None

- **Return:**

None

5.1.46 *DisableSJA1000*

- **Description:**

Call DisableSJA1000() to stop the functions of transmission CAN messages, reception CAN messages and interrupt.

- **Syntax:**

void DisableSJA1000(void)

- **Parameter:**

None

- **Return:**

None

5.1.47 GetCANStatus

- **Description:**

Obtain the status register of SJA1000 by using this function.

- **Syntax:**

int GetCANStatus(void)

- **Parameter:**

None

- **Return:**

The return code is the value of status register of SJA1000. Its meanings is described below.

Bit NO.	Description
7 (MSB)	Bus status. 1 for bus off, 0 for bus on.
6	Error status. 1 for at least one error, 0 for OK.
5	SJA1000 Transmit status. 1 for transmitting, 0 for idle.
4	SJA1000Receive status. 1 for receiving, 0 for idle.
3	SJA1000 Transmit complete status. 1 for complete, 0 for incomplete.
2	SJA1000 Transmit buffer status. 1 for released, 0 for locked
1	Data overrun status. 1 for SJA1000 reception buffer overrun, 0 for OK.
0 (LSB)	Receive buffer status. 1 for at least one message stored in the SJA1000 reception buffer, 0 for empty.

Table 5.5 The Description of Status Register of SJA1000

5.1.48 *ClearDataOverrunStatus*

- **Description:**

When the data overrun status is obtained by using GetCANStatus(), call this function to clear this status.

- **Syntax:**

```
void ClearDataOverrunStatus(void)
```

- **Parameter:**

None

- **Return:**

None

5.1.49 SendCANMsg

- **Description:**

Send a CAN message to software transmission buffer. When the CAN bus is idle, this CAN message will be send to CAN network.

- **Syntax:**

```
int SendCANMsg(char Mode, unsigned long MsgID, char RTR,  
               char DataLen, char *Data)
```

- **Parameter:**

Mode: [input] 0 for 11-bit message ID, 1 for 29-bit message ID.

MsgID: [input] CAN message ID.

RTR: [input] 0 for remote-transmit-request format is not used, 1 for remote-transmit-request is used.

DataLen: [input] Data length of a transmitted CAN message. The maximum value is 8.

*Data: [input] The start address of a buffer used to store the transmitted data of a CAN message.

- **Return:**

_NO_ERR: OK.

_SOFT_BUF_FULL: Transmission software buffer is full. Users need to transmit CAN message later. Or, use function ClearTxSoftBuffer() to clear the CAN transmission buffer.

5.1.50 *ClearTxSoftBuffer*

- **Description:**

Call this function to clear the transmission software buffer of CAN messages.

- **Syntax:**

void ClearTxSoftBuffer(void)

- **Parameter:**

None

- **Return:**

None

5.1.51 GetCANMsg

- **Description:**

Obtain a received CAN message from the software buffer.

- **Syntax:**

```
int GetCANMsg(char *Mode, unsigned long *MsgID, char *RTR,  
              char *DataLen, char *Data, unsigned long *UpperTime,  
              unsigned long *LowerTime)
```

- **Parameter:**

*Mode: [output] The address of a variable used to get the mode of a CAN message. If value is 0, the received CAN message is with 11-bit ID. The 29-bit ID of a CAN message will have value 1.

*MsgID: [output] The address of a variable used to get the CAN message ID.

*RTR: [output] The address of a variable used to obtain the status of this CAN message. 0 for remote-transmit-request format is not used, 1 for remote- transmit-request is used.

*DataLen: [output] The address of a variable used to obtain the data length of a CAN message. The range of this value is from 0 to 8.

*Data: [output] The start address of a buffer used to get the data of a CAN message. Users need to put an 8-byte element array in this filed.

*UpperTime: [output] The address of a variable used to obtain the higher double-word of time stamp of a CAN message.

*LowerTime: [output] The address of a variable used to obtain the lower double-word of time stamp of a CAN message. The unit for UpperTime and LowerTime is 0.1ms.

- **Return:**

_NO_ERR: OK.

_RX_SOFT_BUF_EMPTY: The reception software buffer of CAN message is full. Users need to use ClearRxSoftBuffer() to clear this status when this return code is got.

_SOFT_BUF_FULL: Reception software buffer is full. Users need to use function ClearRxSoftBuffer() to clear the CAN transmission buffer.

5.1.52 *ClearRxSoftBuffer*

- **Description:**

Call this function to clear the reception software buffer of CAN messages.

- **Syntax:**

void ClearRxSoftBuffer(void)

- **Parameter:**

None

- **Return:**

None

5.1.53 *RxMsgCount*

- **Description:**

Call this function to know how many available CAN messages stored in the reception software buffer.

- **Syntax:**

int RxMsgCount(void)

- **Parameter:**

None

- **Return:**

The return code is the numbers of CAN messages stored in reception software buffer.

5.1.54 AddCyclicTxMsg

- **Description:**

Add a cyclic transmission message into the cyclic transmission engine. Afterwards, users can enable or disable this cyclic transmission messages by using EnableCyclicTxMsg() and DelectCyclicTxMsg() functions. Maximum 5 set of cyclic transmission messages can be applied. After adding a cyclic transmission message, the handle for this message will be returned. The less value of handle indicates the higher priority of this cyclic transmission message.

- **Syntax:**

```
int AddCyclicTxMsg(char Mode, unsigned long MsgID, char RTR,  
                  char DataLen, char *Data,  
                  unsigned long TimePeriod, unsigned char *Handle)
```

- **Parameter:**

Mode: [input] 0 for 11-bit message ID, 1 for 29-bit message ID.

MsgID: [input] CAN message ID.

RTR: [input] Set the remote-transmit-request is used or not. 0 is for useless, 1 is for useful.

DataLen: [input] CAN message data length. The maximum value is 8.

*Data: [input] The start address of the data buffer of a CAN message. The maximum space of *Data is 8 bytes.

TimePeriod: [input] The time period of cyclic transmission. This parameter is formatted by 0.1ms. The minimum value is 5.

*Handle: [output] The address of a variable used to get the handle of a cyclic transmission. When users want to enable or disable the specified cyclic transmission, this value must be needed.

- **Return:**

_NO_ERR: OK

_CYCLIC_CONFIG_ERR: The cyclic transmission messages are over 5 messages or the time period is less than 0.5ms.

5.1.55 *DeleteCyclicTxMsg*

- **Description:**

Remove a cyclic transmission message which is added by AddCyclicTxMsg() function before.

- **Syntax:**

int DeleteCyclicTxMsg(unsigned char Handle)

- **Parameter:**

Handle: [input] The handle of the cyclic transmission message which is obtained by AddCyclicTxMsg() function.

- **Return:**

_NO_ERR: OK

_CYCLIC_HANDLE_ERR: The handle value can't be found in the cyclic transmission engine.

5.1.56 *EnableCyclicTxMsg*

- **Description:**

Enable a cyclic transmission message which is added by AddCyclicTxMsg() function before. After enable the specified cyclic transmission message, PISO-CM100-D/T will transmit the specified CAN message by configured time period.

- **Syntax:**

int EnableCyclicTxMsg(unsigned char Handle)

- **Parameter:**

Handle: [input] The handle of cyclic transmission message which is obtained by AddCyclicTxMsg() function.

- **Return:**

_NO_ERR: OK

_CYCLIC_HANDLE_ERR: The handle value can't be found in the cyclic transmission engine.

5.1.57 *DisableCyclicTxMsg*

- **Description:**

Disable a cyclic transmission message which is enabled by EnableCyclicTxMsg() function before.

- **Syntax:**

int DisableCyclicTxMsg(unsigned char Handle)

- **Parameter:**

Handle: [input] The handle of cyclic transmission message which is obtained by AddCyclicTxMsg() function.

- **Return:**

_NO_ERR: OK

_CYCLIC_HANDLE_ERR: The handle value can't be found in the cyclic transmission engine.

5.1.58 *ResetCyclicTxBuf*

- **Description:**

Clear the software buffer of cyclic transmission engine. After calling this function, all of the transmitted cyclic messages stop the procedure, and all of cyclic messages are removed from the cyclic transmission engine.

- **Syntax:**

void ResetCyclicTxBuf(void)

- **Parameter:**

None

- **Return:**None

5.1.59 *SystemHardwareReset*

- **Description:**

Use this function to reset all hardware of PISO-CM100-D/T included 186 CPU.

- **Syntax:**

void SystemHardwareReset(void)

- **Parameter:**

None

- **Return:**

None

5.1.60 *SystemInit*

- **Description:**

Use this function to initiate the DPRAM, LEDs, cyclic transmission engine, CAN transmission software buffer, and CAN controller.

- **Syntax:**

void SystemInit(void)

- **Parameter:**

None

- **Return:**

None

5.1.61 *GetLibVer*

- **Description:**

Get the version of the firmware library.

- **Syntax:**

int GetLibVer(void)

- **Parameter:**

None

- **Return:**

The return code is the version of the firmware library. For example: If 100(hex) is return, it means driver version is 1.00.

5.1.62 *RefreshWDT*

- **Description:**

Call this function to refresh the watchdog of PISO-CM100-D/T. When users design the user-defined firmware, this function must be called where the users' procedure may have a processed period more than 500ms. If RefreshWDT() is not called in 800ms, the 186 CPU of PISO-CM100-D/T will be reset.

- **Syntax:**

void RefreshWDT(void)

- **Parameter:**

None

- **Return:**

None

5.1.63 **UserInitFunc** <must be called once>

- **Description:**

When users design the user-defined firmware, this callback function must be called once. Users can put some procedures into this function. These procedures are those which will be executed only one time in user-defined firmware. When PISO-CM100-D/T boots up, the firmware library will call this callback function once.

- **Syntax:**

void UserInitFunc(void)

- **Parameter:**

None

- **Return:**

None

5.1.64 UserLoopFunc *<must be called once>*

- **Description:**

When users design the user-defined firmware, this callback function must be called as soon as possible. Users can put their main procedures into this function. Then, the main procedure will be executed in every period of time. The time period is correlated with the complexity of users' main procedure. When PISO-CM100-D/T boots up, the firmware library will call UserInitFunc() once and then call UserLoopFunc() in every period of time until PISO-CM100-D/T is turned off. It is not allowed to put a infinite loop in this function.

- **Syntax:**

void UserLoopFunc(void)

- **Parameter:**

None

- **Return:**

None

5.2 Firmware Library Return Codes Troubleshooting

If default firmware is used, users do not need to read this section.

Return Code	Error ID	Troubleshooting
-19	_SET_TIME_ERROR	1. Check the time format of input parameters, and retry it again.
-18	_SET_DATE_ERROR	1. Check the date format of input parameters, and retry it again.
-9	_ACCESS_NVRAM_FAILE	1. Try it again. 2. Call your distributor to solve this problem.
0	_NO_ERR	OK
1	_COUNT_DOWN_TIMER_TIME_UP	1. The countdown timer started by users is timeout.
101	_CAN_CHIP_SOFT_RESET_ERR	1. Call SJA1000HardwareReset(), and try it again. 2. Call your distributor to solve this problem
102	_CAN_CHIP_CONFIG_ERR	1. Check the parameters of baud, BT0, BT1, acceptance code, and acceptance mask, and try it again.
103	_RX_SOFT_BUF_EMPTY	1. Wait for a while and call the function again.
104	_SOFT_BUF_FULL	1. Use function ClearTxSoftBuffer() or function ClearRxSoftBuffer() to clear the status of buffer overflow. 2. Reduce the bus loading of CAN network.
105	_DPRAM_WRITE_ERR	1. Wait for a while and call the function again. 2. Call your distributor to solve this problem
106	_DPRAM_READ_ERR	1. Wait for a while and call the function again. 2. Call your distributor to solve this problem.
107	_DPRAM_OVER_RANGE	1. Check the address or space range of written DPRAM, and try it again.
108	_NO_DPRAM_CMD	1. Wait for a while and call the function again.

Return Code	Error ID	Troubleshooting
109	_CYCLIC_CONFIG_ERR	<ol style="list-style-type: none"> 1. Check if users already use 5 the cyclic messages. 2. Set the parameters TimePeriod to more than 5.
110	_CYCLIC_HANDLE_ERR	<ol style="list-style-type: none"> 1. Check the parameter Handle, and try it again.
111	_EEPROM_OVER_RANGE	<ol style="list-style-type: none"> 1. Check the address or space range of written EEPROM, and try it again.
112	_EEPROM_ACCESS_ERROR	<ol style="list-style-type: none"> 1. Wait for a while and call the function again. 2. Call your distributor to solve this problem.

Table 5.6 Return Code Troubleshooting

Note: If users' problem can't be fixed after following the recommended methods. Please contact your distributor or email to service@icpdas.com to solve the problem.

6 Application Programming

In this chapter, the operation procedure of PISO-CM100-D/T is shown about how to use default firmware and design user-defined firmware. Section 6.1 describes the procedures of programming an application and briefs some demo programs. Section 6.2 introduces the CANUtility tool. It is a useful tool for monitoring and accessing the CAN network. Furthermore, when users want to update the default firmware or download user-defined firmware into PISO-CM100-D/T. This tool must be used. Section 6.3 gives a profile about how to design the user-defined firmware, and the corresponding application on Windows platform. Some demo programs for user-defined firmware are also shown. Section 6.4 provides two ways to debug the user-defined firmware. If users just use the default firmware, the Section 6.3 and 6.4 can be ignored.

6.1 *Windows Programming With Default Firmware*

This section is only for default firmware. It is useless if users use the user-defined firmware. Figure 6.1 presents the “Send CAN Message” procedure. When users want to design their application by using the APIs of CM100.dll on Windows platform, this flow chart may be a good reference. Figure 6.2 is a standard procedure for receiving a CAN messages. This procedure let users obtain the CAN messages from CAN bus easily. If users need to send some specified CAN messages every period of time, the flow chart shown in figure 6.3 may give a good example. Owing to these three procedures, it may satisfy most applications of users' Windows applications with default firmware of PISO-CM100-D/T. Following the operation principle of PISO-CM100-D/T can help users with building their applications easier and faster. When users want to combine these three procedures for various applications, the functions, CM100_ActiveBoard(), CM100_Init(), and CM100_Config(), are only called once when the program starts. If the program needs to be terminated, call the function CM100_CloseBoard() once to release the resource of PISO-CM100-D/T back to the system.

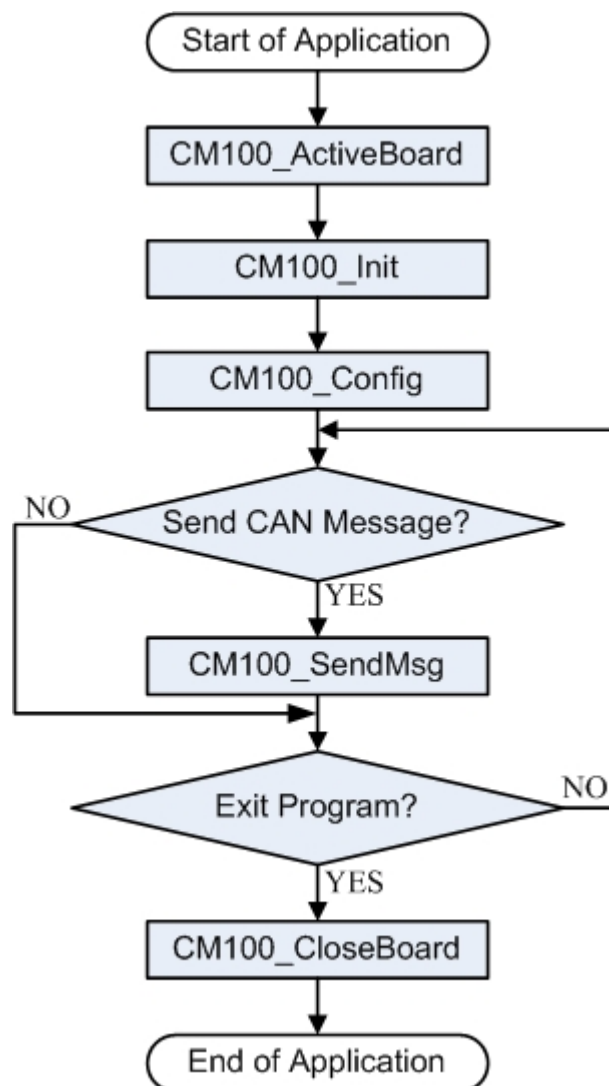


Figure 6.1 Flow Chart of Sending CAN Messages

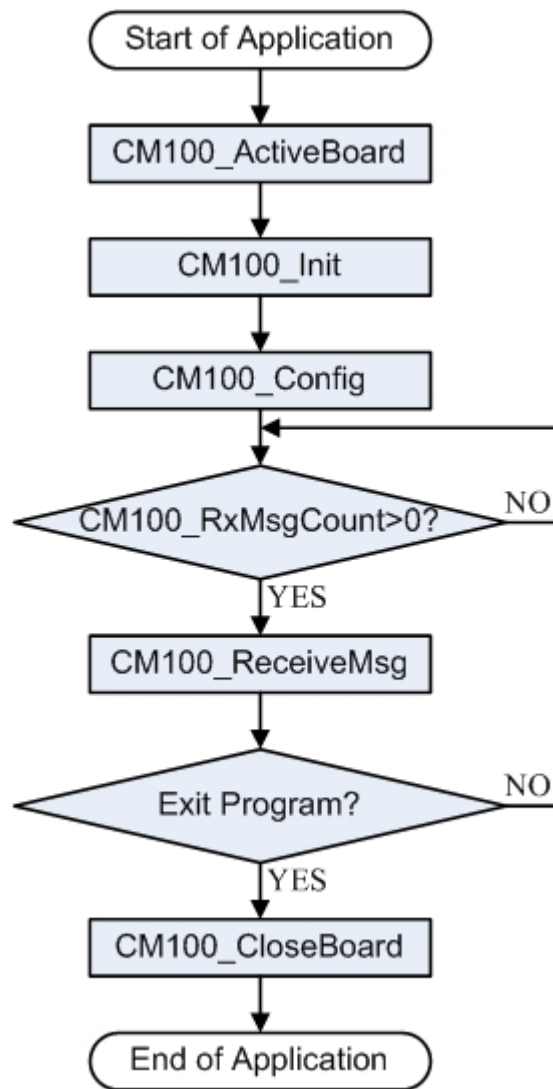


Figure 6.2 Flow Chart of Receiving CAN Messages

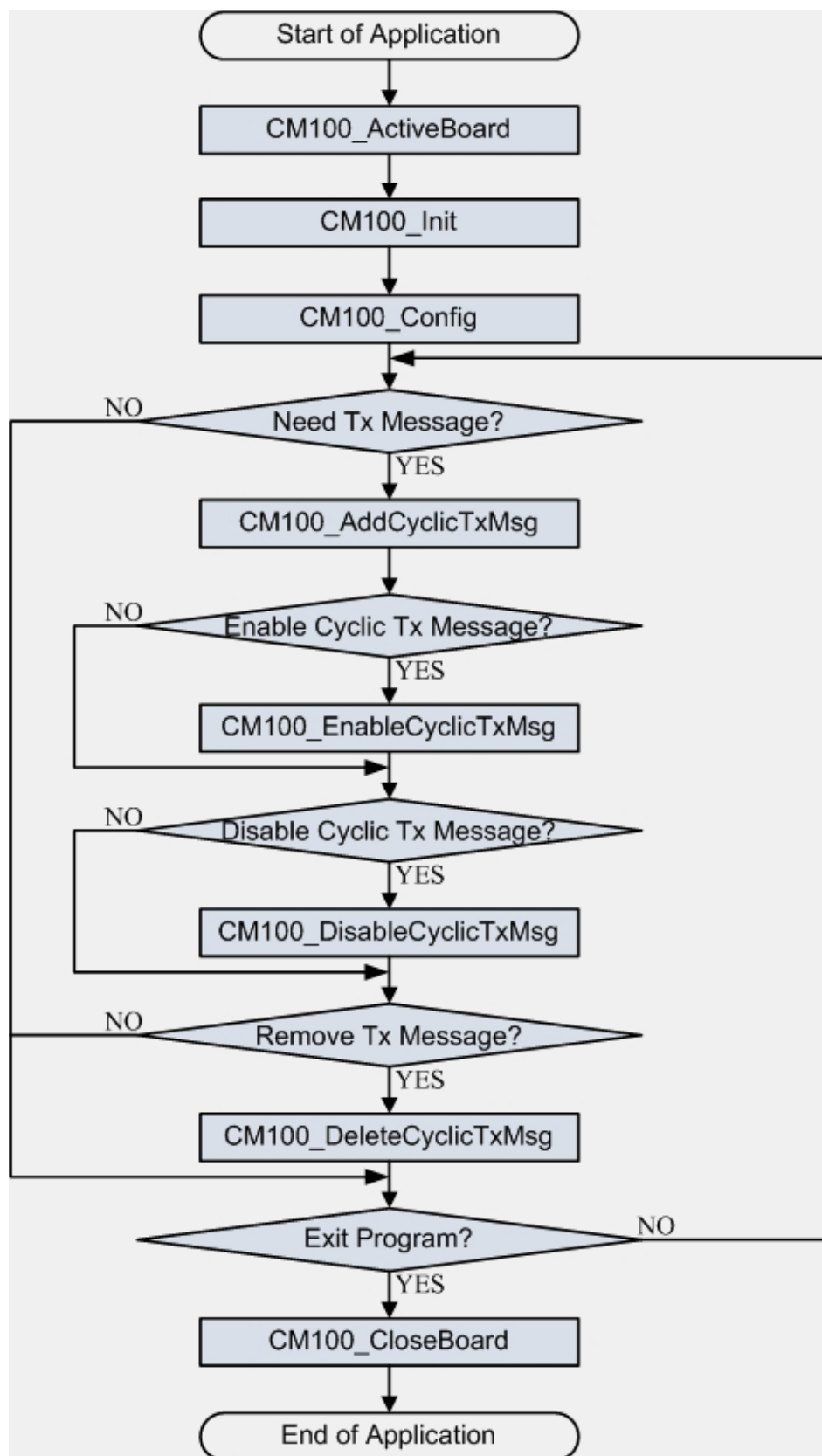


Figure 6.3 Flow Chart of Cyclic Transmitting CAN Messages

Briefs of the demo programs:

All of demo programs described here need to assist with the default firmware of PISO-CM100-D/T. Each demo can't work normally if DLL driver would not be installed correctly. During the installation process of DLL driver, the installation program also copy the demo programs to the proper position which is based on the path selected before. After installing the driver installation, the related demo programs, development library and declaration header files for different development environments are presented as following.

--\Demos	→ PISO-CM100-D/T demo programs
--\For_Default_Firmware	→ For default firmware
--\BCB	→ For Borland C++ Builder 3
--\Library	→ Folder for library
--\ReceiveMsg	→ Demo for getting CAN messages
--\TransmitMsg	→ Demo for sending CAN messages
--\TransmitMsgCyclically	→ Demo for sending CAN messages cyclically
--\VC++	→ for Visual C++ 6.0
--\Library	→ Folder for library
--\ReceiveMsg	→ Demo for getting CAN messages
--\TransmitMsg	→ Demo for sending CAN messages
--\TransmitMsgCyclically	→ Demo for sending CAN messages cyclically
--\VB	→ For Visual Basic 6.0
--\Module	→ Folder for library
--\ReceiveMsg	→ Demo for getting CAN messages
--\TransmitMsg	→ Demo for sending CAN messages
--\TransmitMsgCyclically	→ Demo for sending CAN messages cyclically
--\Default_Firmware	→ Default firmware copy

ReceiveMsg:

ReceiveMsg demo is a sample example for demonstrating about how to receive CAN messages from CAN network by using PISO-CM100-D/T APIs with the default firmware. The dialog of this demo is shown as figure 6.4



Figure 6.4 Dialog of ReceiveMsg Demo Program

Select the CAN baud and board No. of the specified PISO-CM100-D/T. Click “Active Board” button to start this demo. Afterwards, the title of dialog will display the name of activated board. The SJA1000 status shown in the status filed will be updated every 500ms. Click “Clear Status” button when the buffer of SJA1000 is overflow. If there are any CAN messages received by PISO-CM100-D/T, users need to click Receive button to get these CAN messages from reception software buffer. Of cause, users can put this part of demo codes into timer function or thread. Therefore, the action of receiving messages will always be checked by program instead of manual operation. If users need to clean the message list in the bottom of this dialog, click Clear List button to do this.

TransmitMsg:

This demo is very useful if users want to send CAN message. The dialog of TransmitMsg demo is shown as figure 6.5.

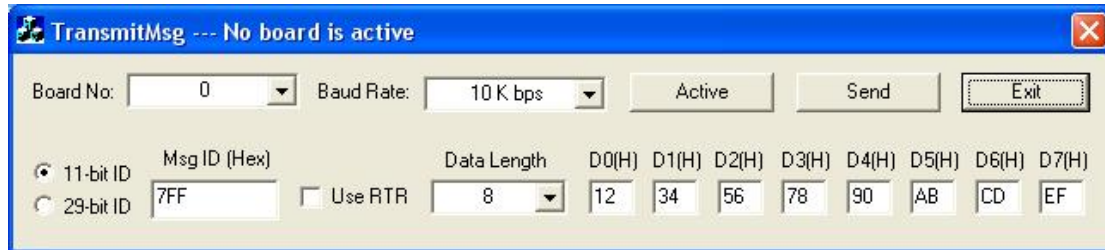


Figure 6.5 Dialog of TransmitMsg Demo Program

As the description above, Select the CAN baud and board No. of the specified PISO-CM100-D/T firstly. Then, click “Active Board” button to start this demo. The title of dialog will display the name of activated board. After filling the all parameters of a CAN message, users can click “Send” button to send it out.

TransmitMsgCyclically:

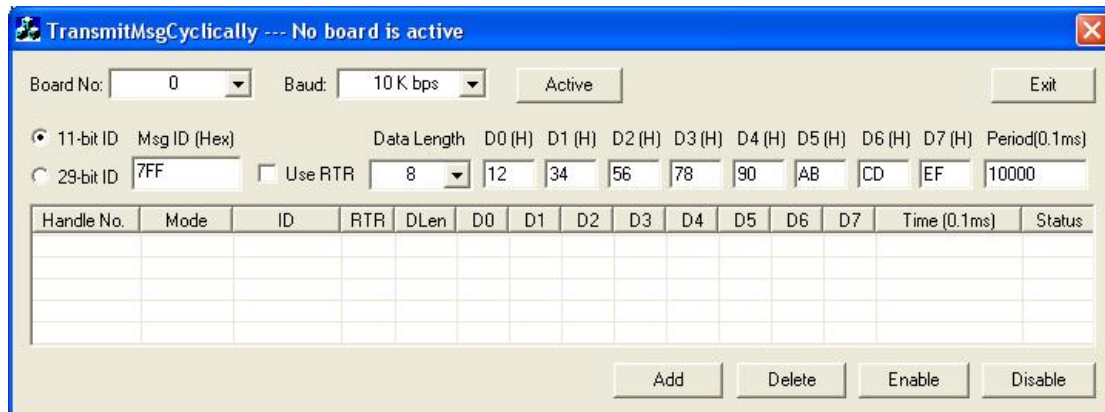


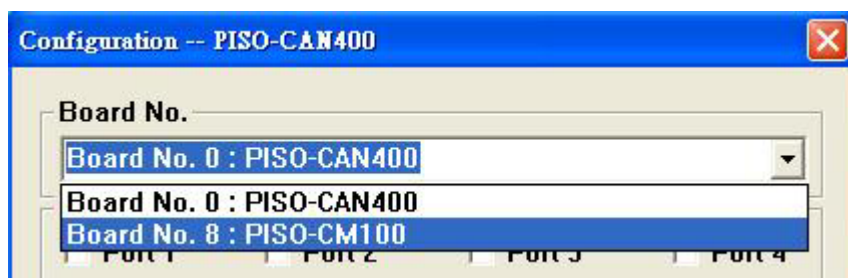
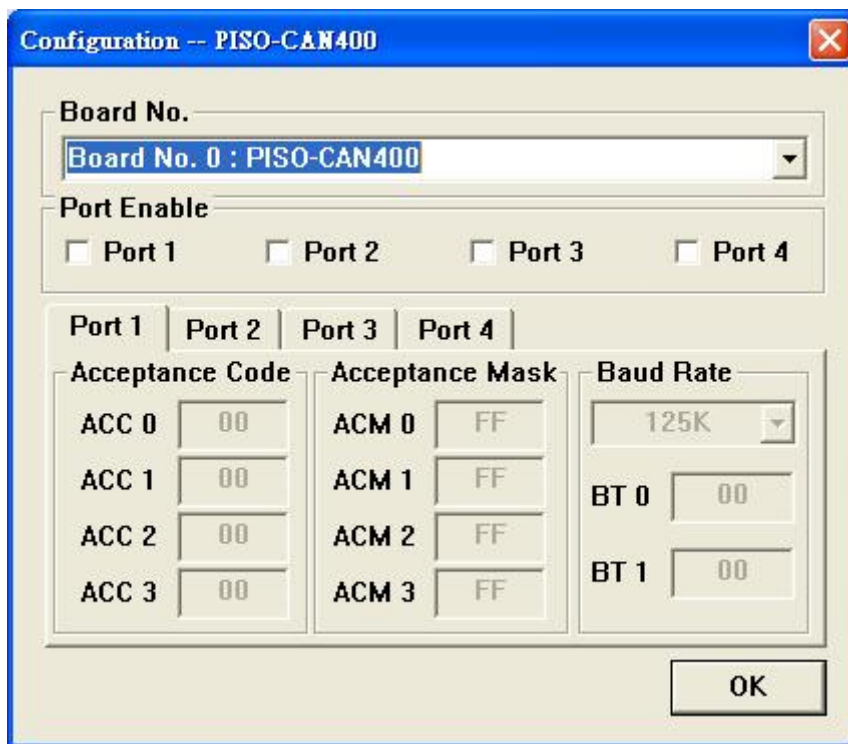


Figure 6.6 Dialog of TransmitMsgCyclically Demo Program

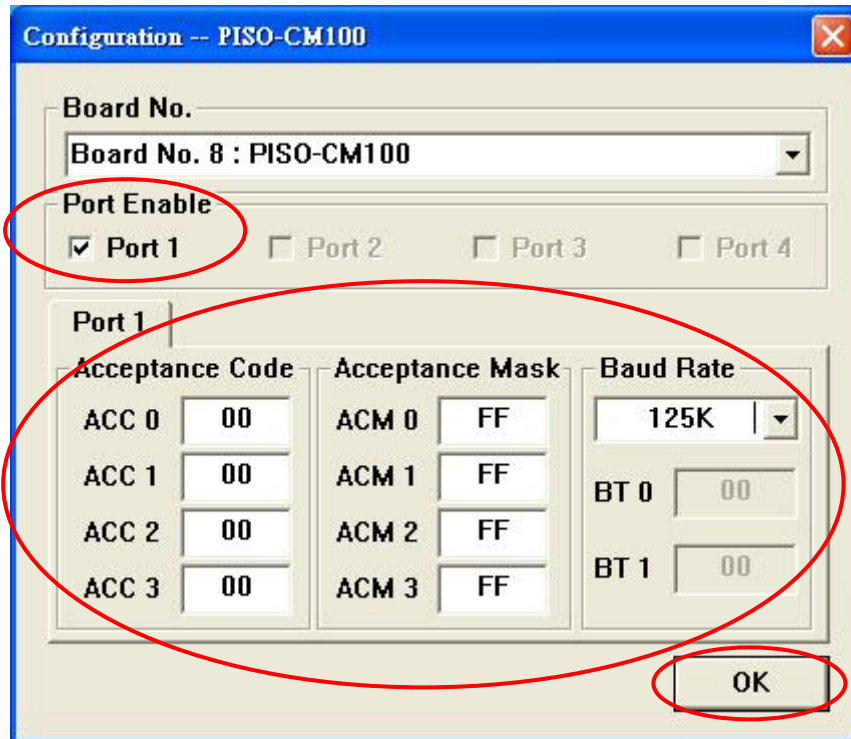
The dialog is shown as figure 6.6. Firstly, select board No., baud and click “Active” button to activate the specified PISO-CM100-D/T. Secondly, configure all parameters of the cyclic CAN message. Be careful that the parameter Period is the unit of 0.1ms. The value of this parameter must be over 5. Then, click “Add” button to add this message into the cyclic transmission engine. This message will also be shown in the message list in the bottom of the dialog. Afterwards, users can select a cyclic message listed in the message list, and click “Enable” button to start the message transmission. If users want to stop it, select it from message list, and click “Disable” button. The action of deleting the cyclic message from cyclic transmission engine is similar with the action of disable a cyclic transmission. Just select the cyclic message from message list, and click “Delete” button.

6.2 Introduction of CANUtility Tool

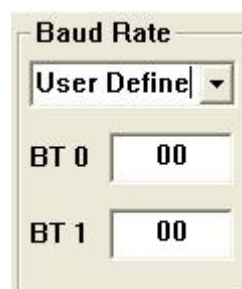
CANUtility is designed for PISO-CAN200D/T, PISO-CAN400-D/T or PISO-CM100-D/T. It provides some useful functions when users want to debug users' CAN application, monitor some CAN devices and access a CAN network. Users can find it in the folder of PISO-CM100-D/T where you installed the driver before. The default path is "c:\ICPDAS\PISO-CM100". When you execute the CANUtility.exe, the Configuration dialog is popped up below. All PISO-CAN200-D/T, PISO-CAN400-D/T and PISO-CM100-D/T will be listed in the Board No. filed  users do not want to do configuration, click  to skip this procedure. Here, select PISO-CM100-D/T for demonstration.



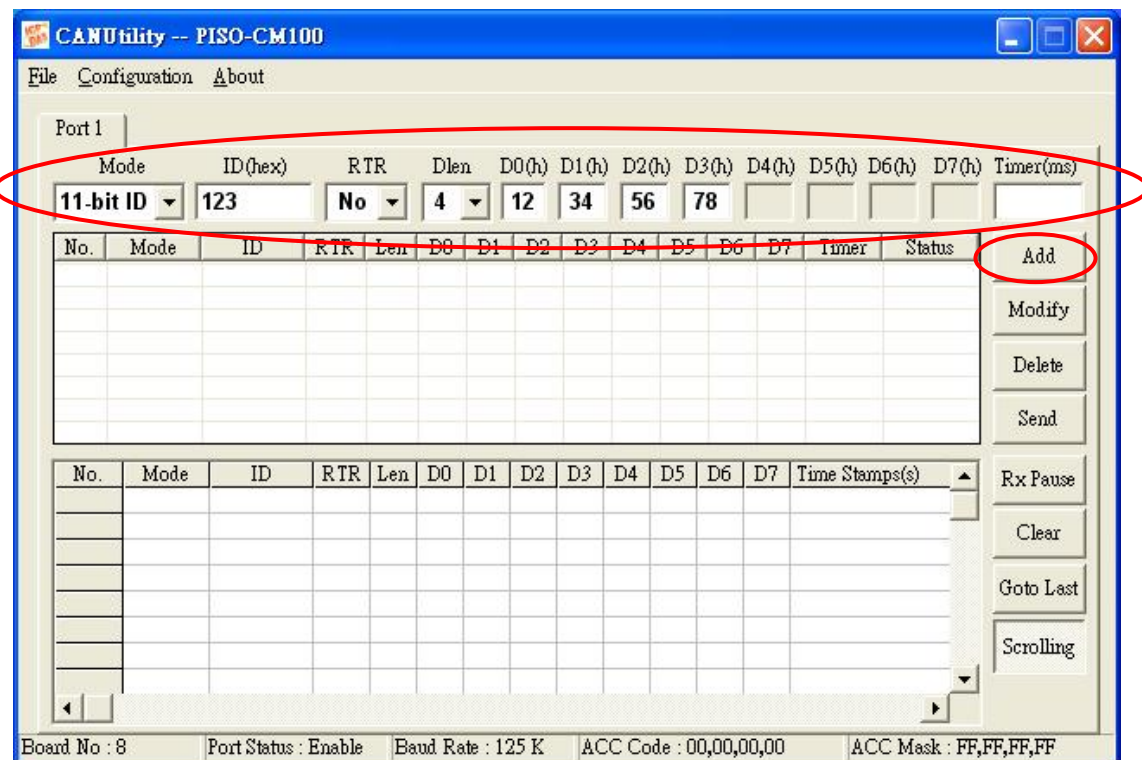
Because PISO-CM100-D/T has only one CAN port, the Port2, Port3 and Port4 are disable. Check the Port1 to enable it. Afterwards, you can modify the parameters of acceptance code, acceptance mask and baud. Section 4.1.28 can give a good reference about how to set acceptance code and acceptance mask.



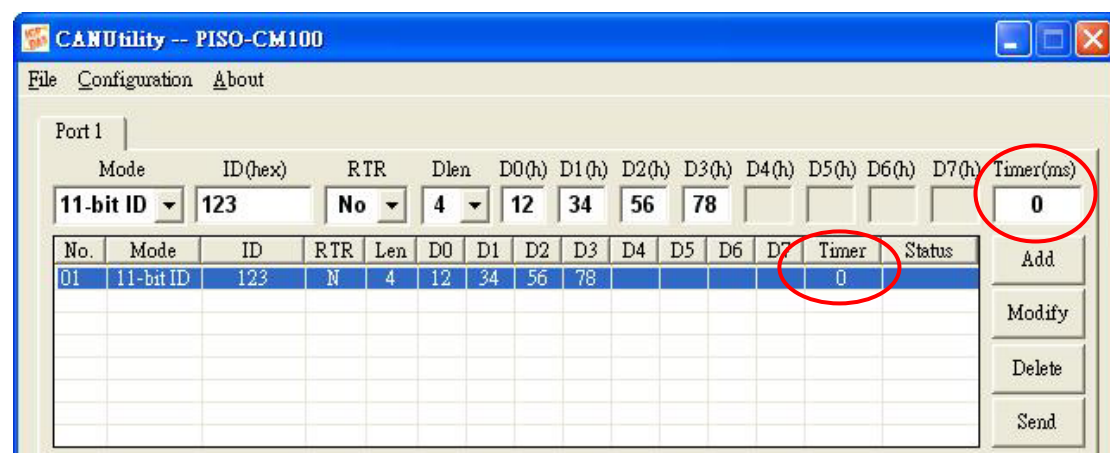
If the proper baud can't be found in the Baud list, select "User Define" to define special baud by using BT0 and BT1 of SJA1000. In this case, users need to study the datasheet of SJA1000 to know how to use BT0 and BT1 register to configure baud.



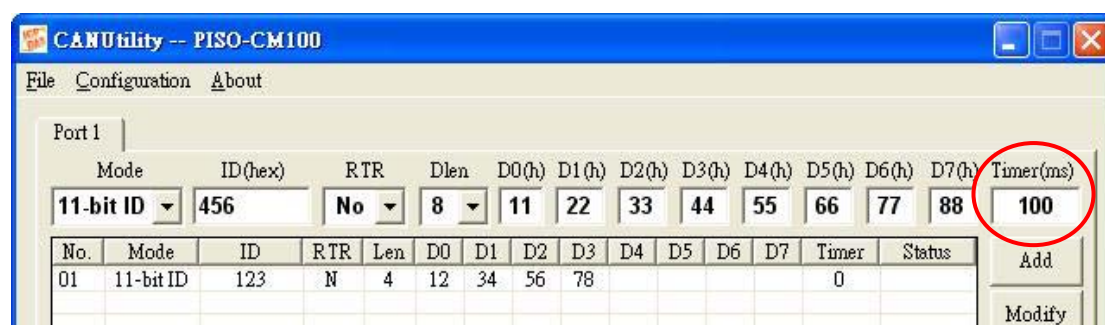
After finishing the configuration and clicking “OK” button, the main screen of CANUtility is displayed. The title of CANUtility shows the activated board name. The status of this board is shown on the status bar in the bottom of the window.



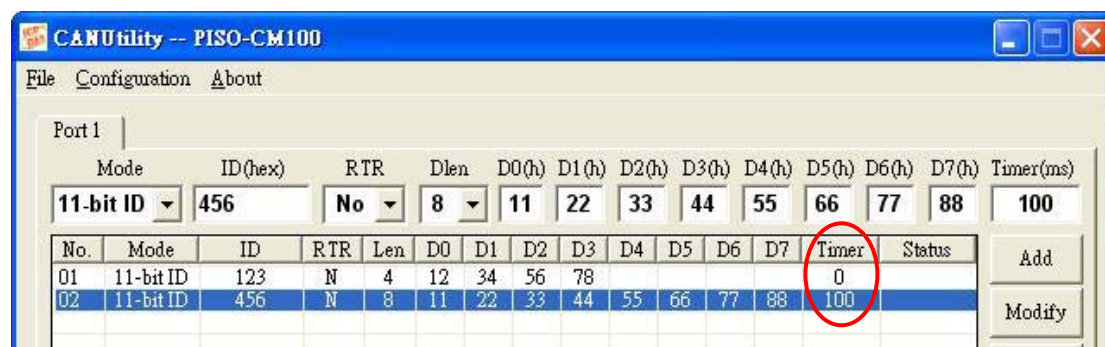
Users can set the parameters of a transmitted CAN message, and click Add button to put it into list. If users just need to send one CAN message, please let the Timer filed to be 0 or empty.



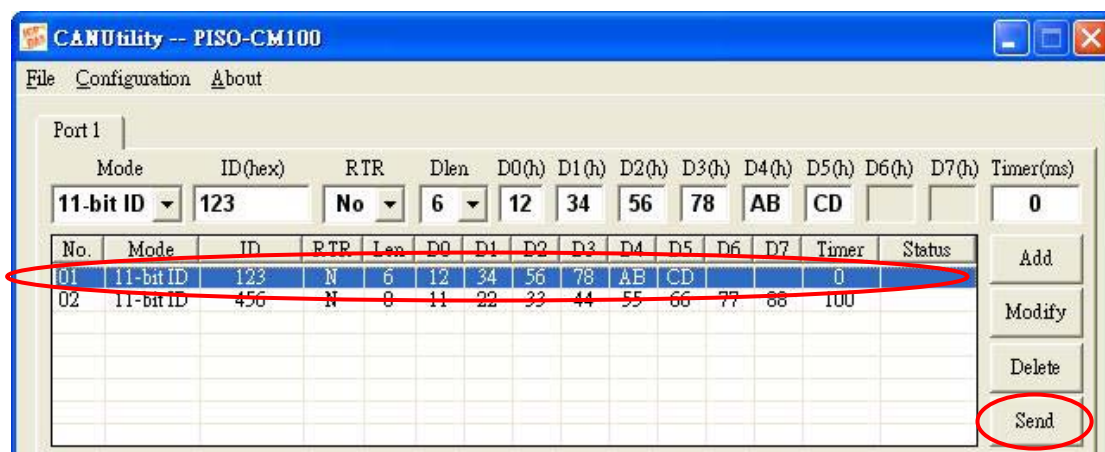
If cyclic transmission messages are demanded, users can configure the message parameters with timer filed.



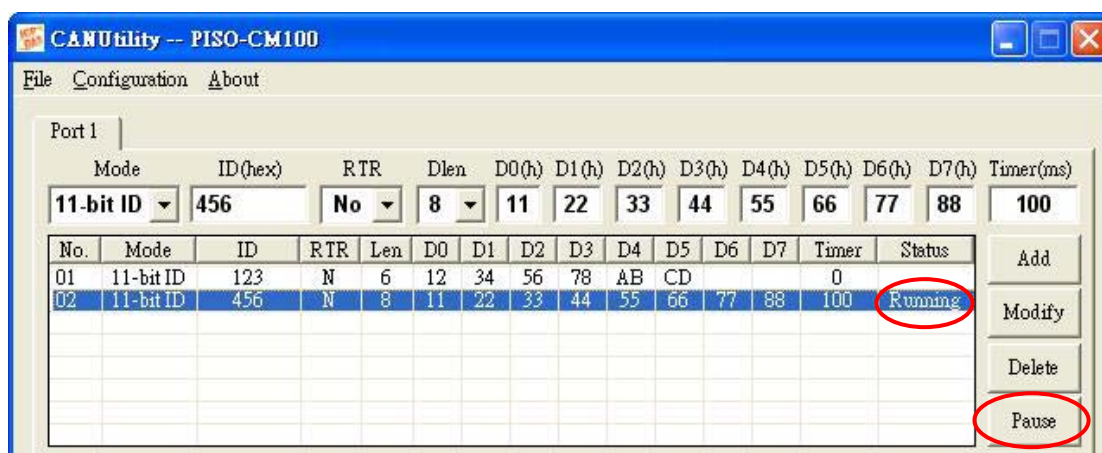
After finishing the configuration, click Add button to add the cyclic transmission message into list.



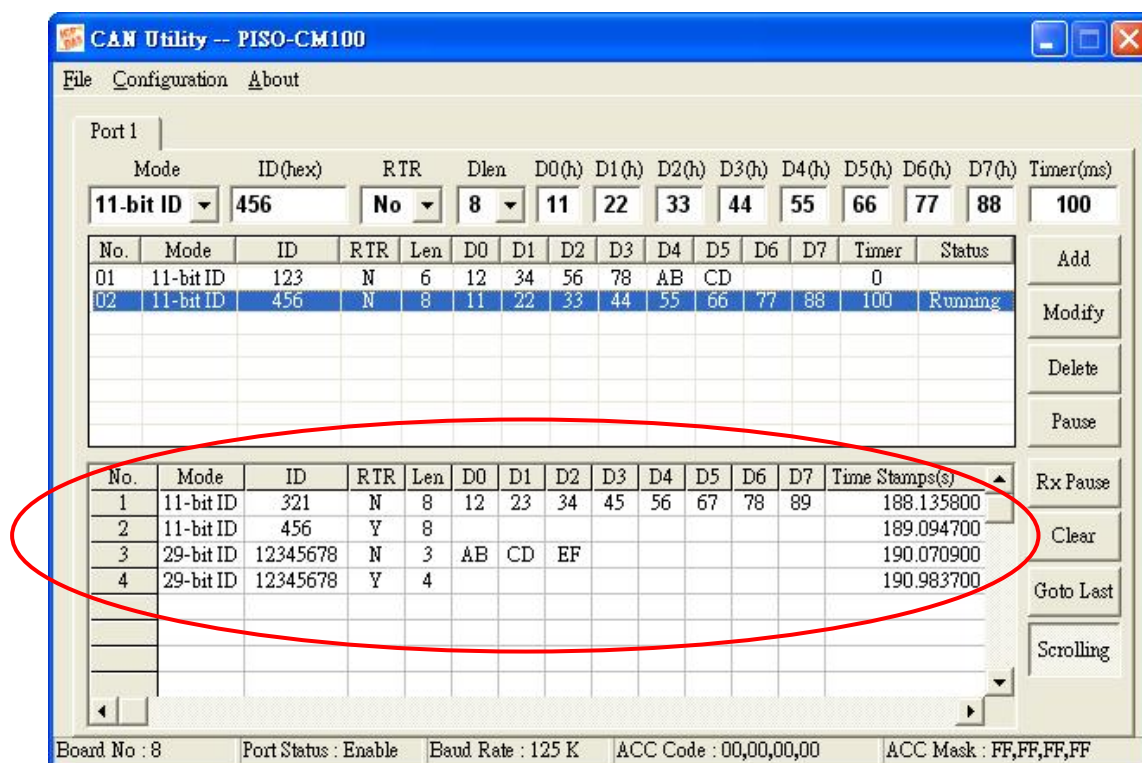
When CAN messages are added into list, the PISO-CM100-D/T will not send them to CAN network until users click Send button. Therefore, select the CAN messages which you want to send from the list, and click "Send" button to send it.



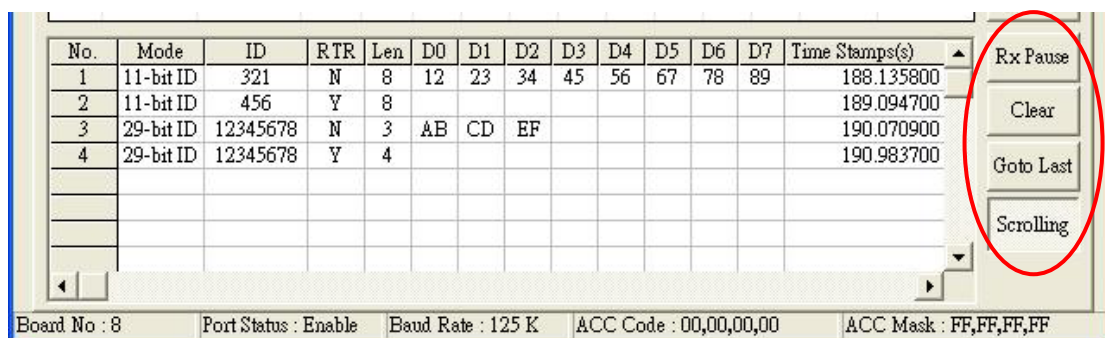
Similarly, select the cyclic transmission messages from list, and click Send button to send the cyclic transmission. Afterwards, the status of sent cyclic transmission message is changed to “Running”, and the “Send” button is also changed to “Pause” button. Therefore, if users want to stop the transmission, select the sent cyclic transmission message from list, and click Pause button to stop it.



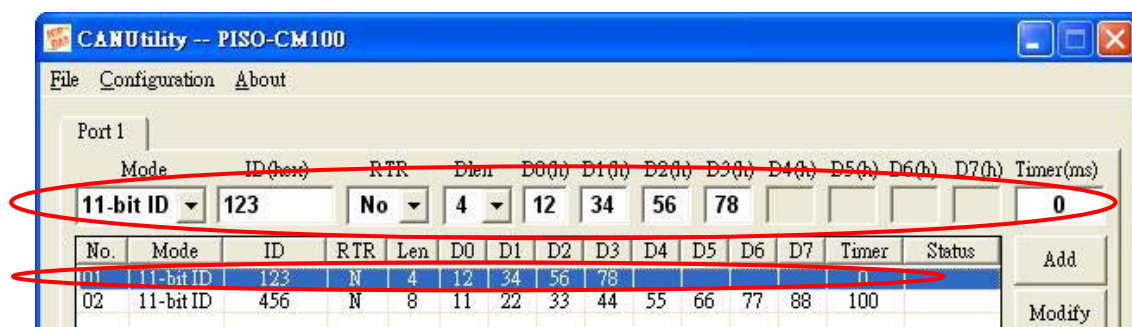
If any CAN message is obtained by CANUtility, it will be put into the reception list in the bottom of the window. Time Stamps filed shows the time when a message is got. The time base is the initial time of PISO-CM100-D/T.



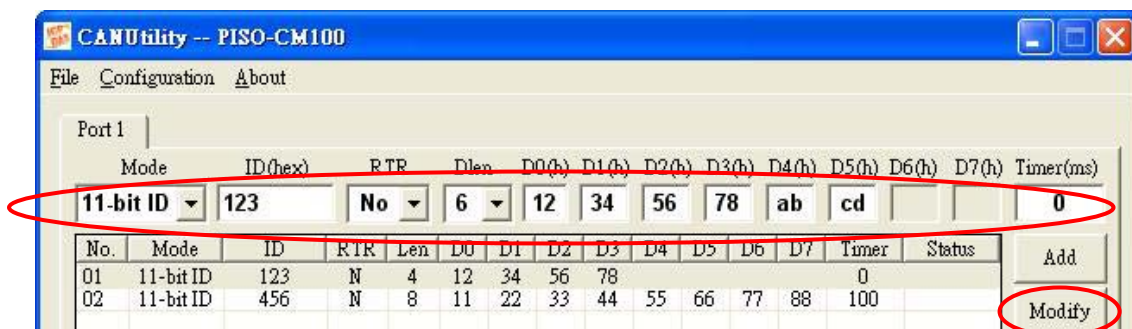
Users can click “Rx Pause” button to pause the reception of CAN messages. Or click this button again to continue. Click “Clear” button to empty the reception list. The “Goto Last” button is used to move the scroll bar of the reception list to the last record of received CAN message. If the Scrolling button is activated as the following figure, the reception list will be scrolled automatically when any CAN message is received. If the Scrolling button is inactivated, the auto-scrolling stops, but the received CAN messages are still put into reception list still.



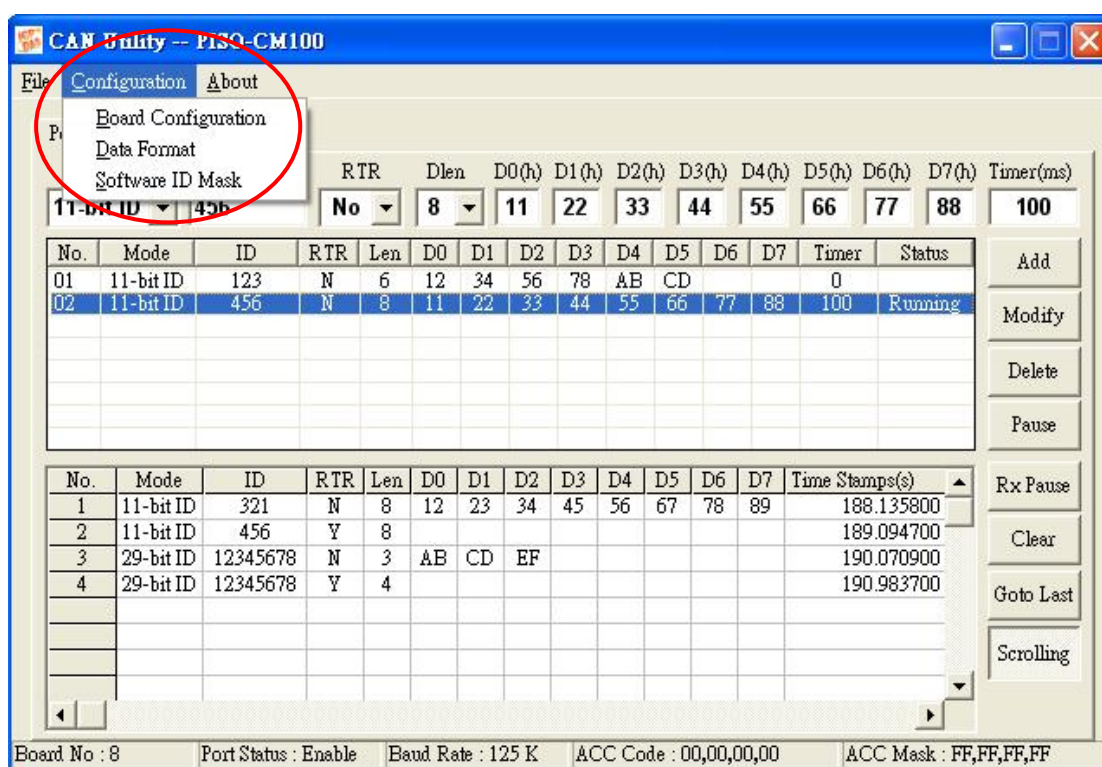
If users want to modify the parameters of the CAN message added before, select the specified CAN message from list. Then the configuration fields will be filled with the parameters of the specified CAN message.



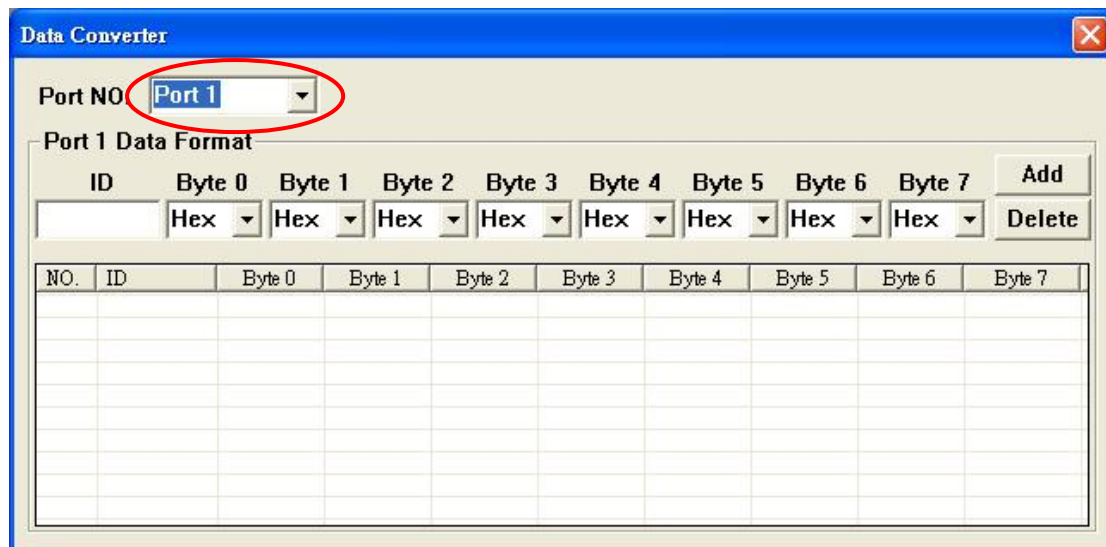
Users can modify the parameters in these configuration fields. Then, click Modify button to modify it.



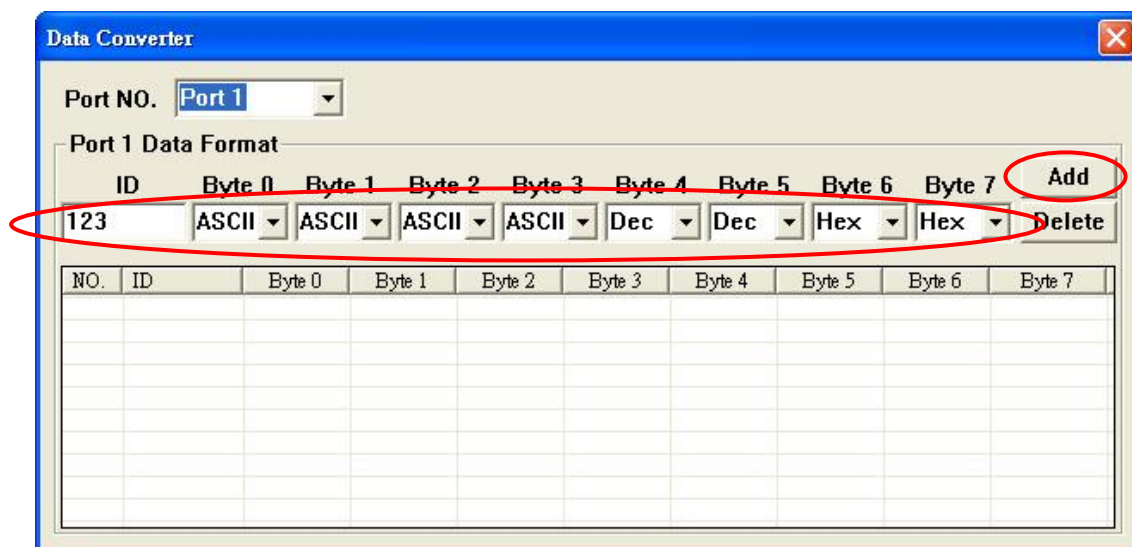
The CAN utility also provide special functions when reading CAN data. For example, some CAN messages with specified message ID need to be notified. Or, the some bytes of data of a CAN message need to transfer to ASCII characters. Such kinds of demands, users can use the functions of Configuration item of menu to achieve these purposes. Board Configuration function let users modify the configuration of specified board. It is the same as the dialog when CANUtility.exe is starting. Data Format function provides a human interface to set the data format for each byte of data of a specified CAN message. Software ID Mask function is similar with the functions of acceptance code and acceptance mask of Configuration dialog popped up in the start of CANUtility.exe. The former uses software method to filter the useless CAN message, the latter users hardware method to do this. The feature of Software ID Mask is that it allows users to filter any CAN messages which you wouldn't need to see. It is more flexible than setting acceptance code and acceptance mask. But its performance is not good enough as the hardware message filter.



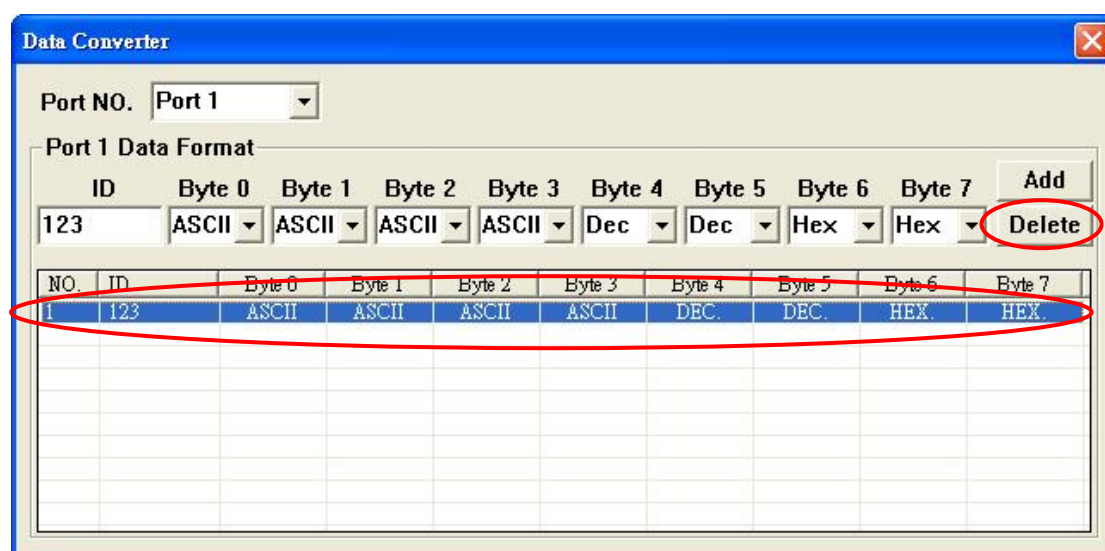
After clicking the item of Data Format, the Data Converter dialog is popped up. Users can select the port No. to confirm the received messages from the specified port need to convert.



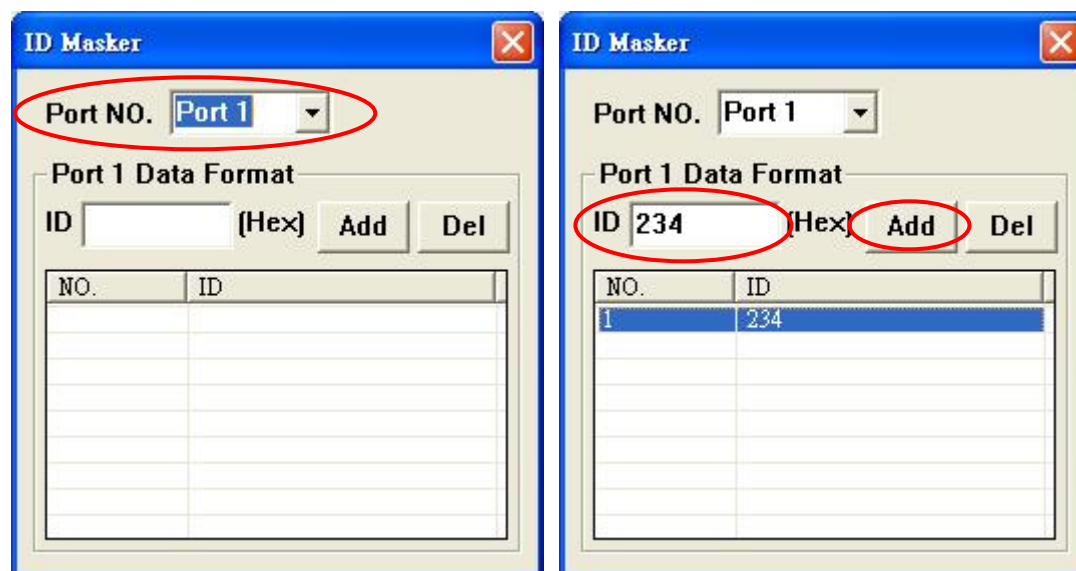
When finishing the settings of data format for the specified message ID, click Add button to save the configuration. Here, provide three kinds of data format. There are Hex., Dec. and ASCII. The default setting for received CAN messages is hexadecimal format.



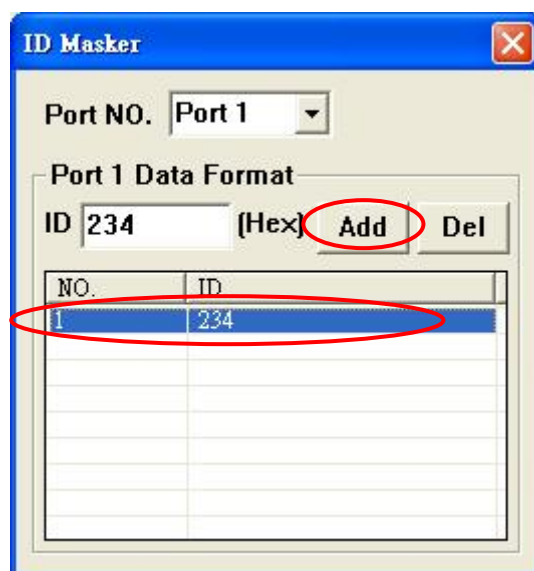
If users want to cancel the configuration which is set before, select the record from the list firstly, then click “Delete” button to remove it.



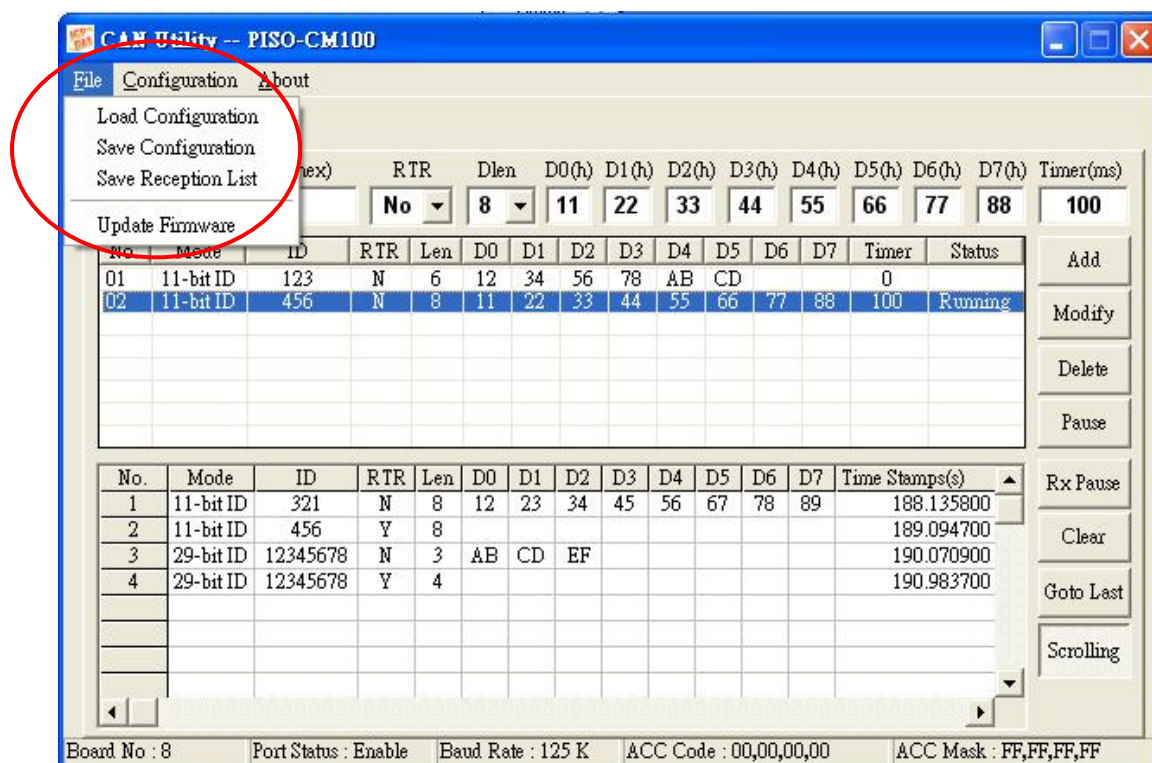
The “Software ID Mask” function is executed in “ID Masker” dialog. Select port No. firstly. Then, fill the message ID of CAN messages which you want to drop. Finally, click “Add” button to store the result.



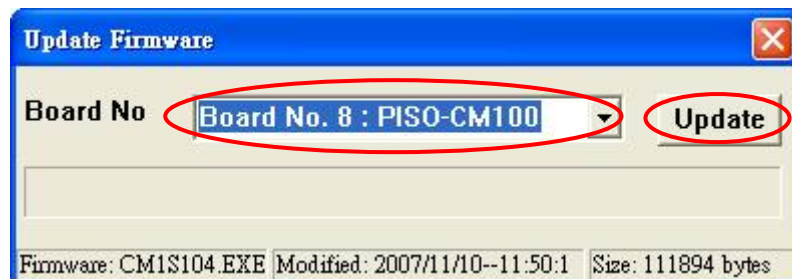
If you want to remove the configuration which is set before, select the record from list, and click Del button. The maximum number of mask ID is 20.



Besides the functions described above, CANUtility allows users to save and load the configuration parameters by clicking “File” item of menu. And use Load Configuration or Save Configuration to do this. Save Reception List function help users to store the records of received CAN messages into .txt file. The Update Firmware function let users update the default firmware or download the user-defined firmware. This function is only for PISO-CM100 series cards, not for PISO-CAN200-D/T or PISO-CAN400-D/T.



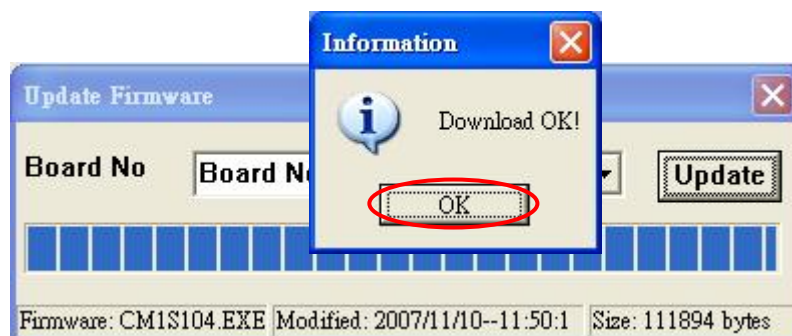
When users apply the Update Firmware function, select the specified board firstly. Only PISO-CM100-D/T, PISO-CPM100-D/T and PISO-DNM100-D/T are listed in the Combo box. Then, click Update button to select the proper firmware for the specified board.



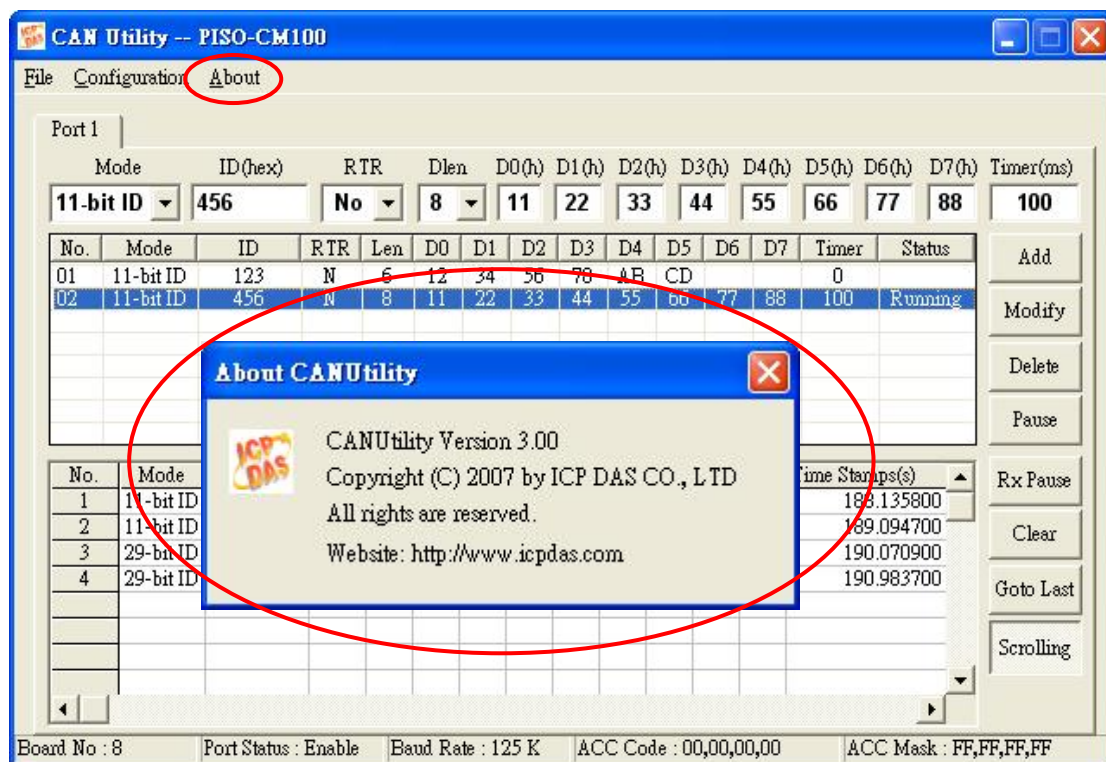
Only .exe file can be downloaded into PISO-CM100 series.



When finishing the download procedure, the Download OK dialog is popped up. Click OK button to continue.



If users want to check the version of CANUtility, click About item of menu to get the information.

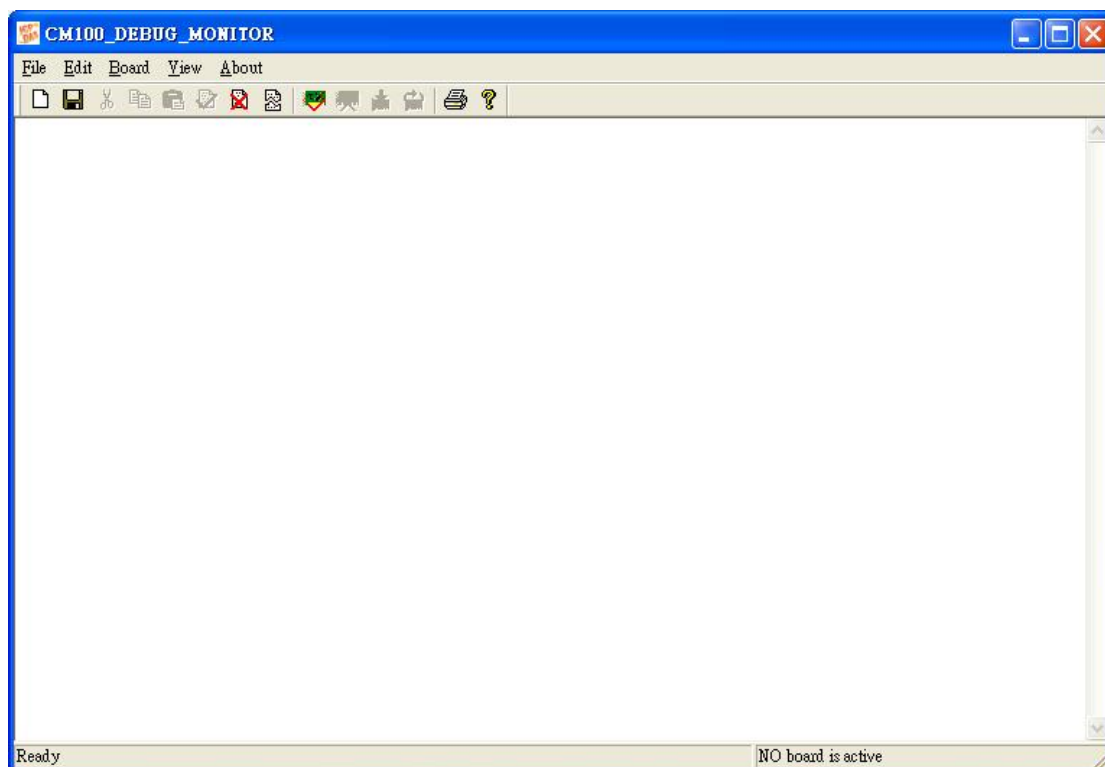


6.3 Debug Tools for User-defined Firmware Programming

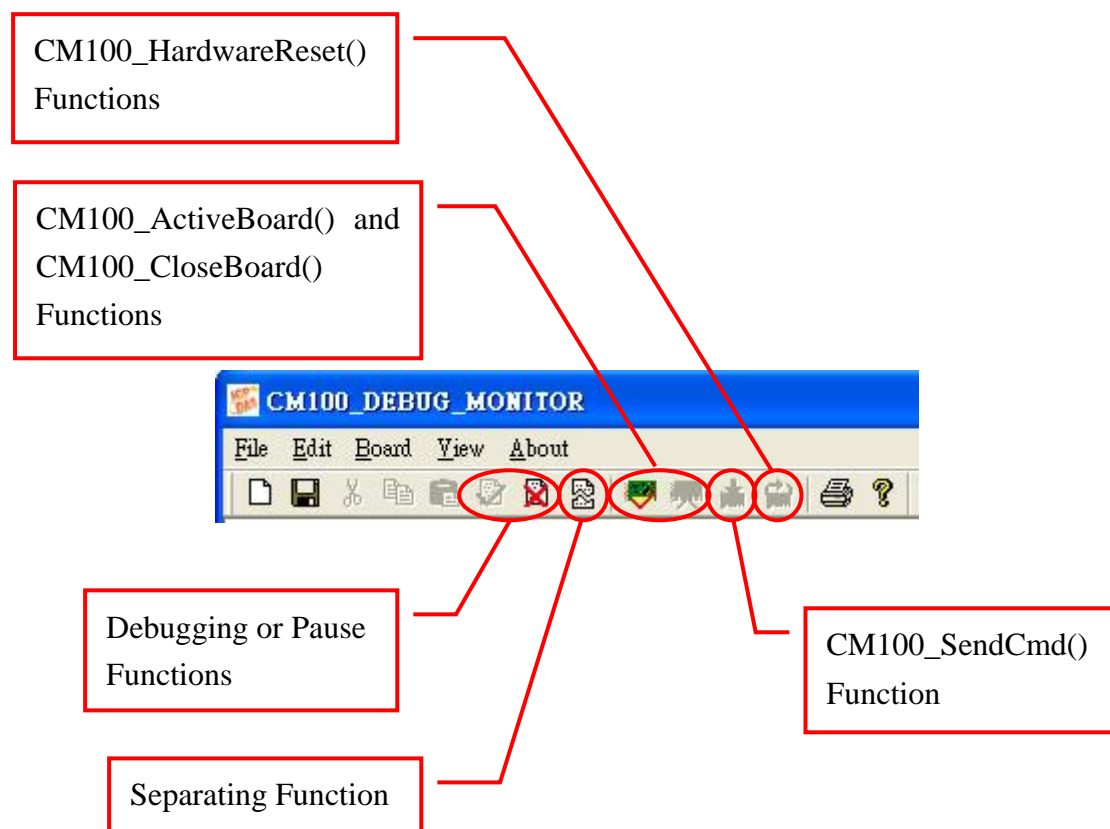
If users just apply default firmware for their application, this section can be ignored. This section introduces the debug methods when users design their firmware. Basically, when users develop the user-defined firmware, the debug message can be put into the code section of user-defined firmware which may have bugs inside. Then, compile user-defined firmware, and download it into PISO-CM100-D/T. Owing to check the debug message, the bugs could be found. There are two methods for checking the debug messages. One is that use CM100_DEBUG_MONITOR.exe to check the debug information. Another is that use 7188xw.exe assisted with debug cable. In the following description, these two methods will be detailed sequentially.

CM100_DEBUG_MONITOR.exe:

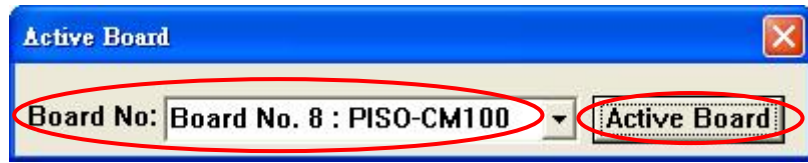
If the functions DebugPrint() is applied in the user-defined firmware. Users need to check the debug message by using CM100_Debug_Monitor.exe. It is displayed as following figure. Users can find it in the Field Bus CD. The path is CAN\PC\PISO-CM100\.



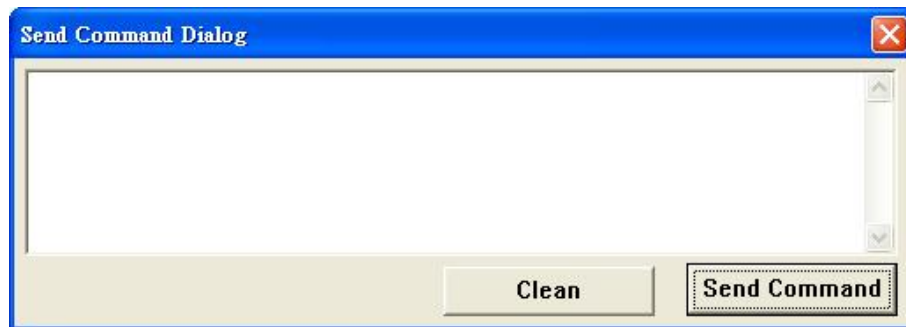
Because of the software architecture of PISO-CM100-D/T, the CM100_Debug_Monitor.exe is useful when the PISO-CM100-D/T is activated. Therefore, this debug program provides CM100_ActiveBoard() function and CM100_CloseBoard() function. If users want to send some commands to user-defined firmware or restart the user-defined firmware, they are also provided by CM100_SendCmd() and CM100_HardwareReset() functions in CM100_DEBUG_MONITOR.exe. These functions are built in the tool bar as below.



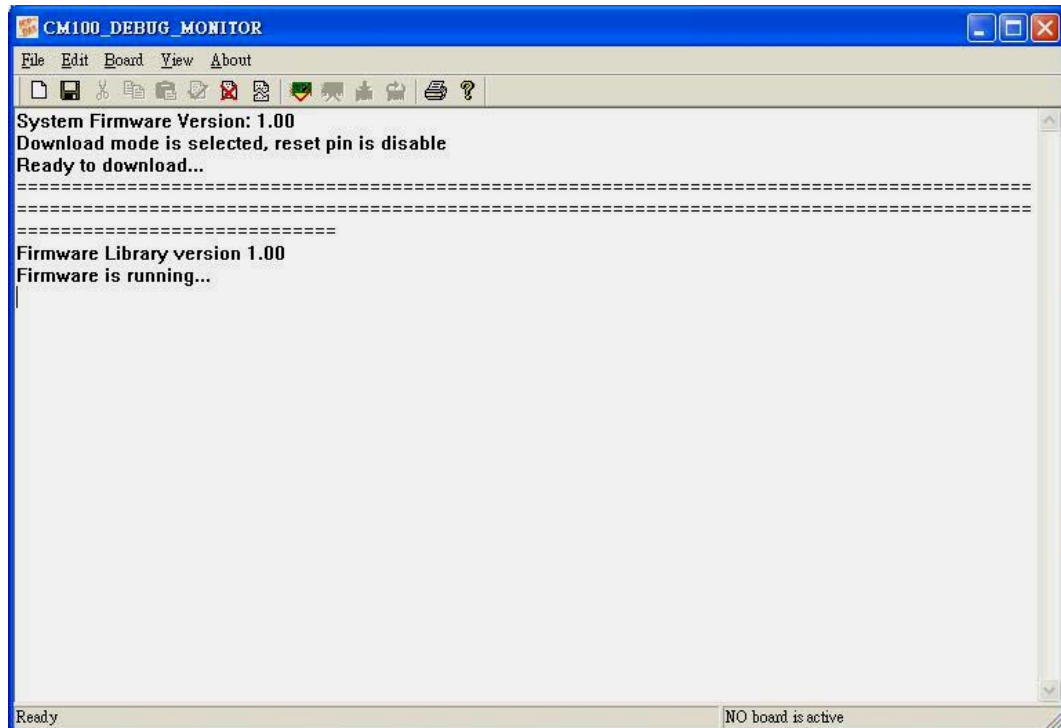
If any other program has activated the specified PISO-CM100-D/T, the CM100_ActiveBoard() and CM100_CloseBoard() of CM100_DEBUG_MONITOR.exe are not needed because one PISO-CM100-D/T can be activated by only one program at the same time. After clicking the CM100_ActiveBoard() function, the dialog is popped up as below.



Users can select the proper board name and click “Active Board” button to activate this board. When board is activated, users can use CM100_SendCmd() function to send command to the user-defined firmware. The dialog of sending command is shown below. Users can key the ASCII string in the edit box and click Send Command to user-defined firmware. If users need to clean the edit box, use Clean button to do this.

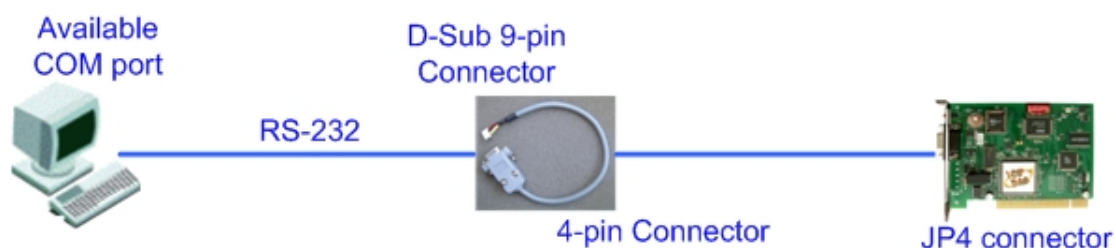


The debugging and pause function are used to decide if the CM100_DEBUG_MONITOR.exe is receiving the debug messages or not. If not, the debug messages will be dropped. The separating function is applied when users want to separate the debug messages. After using this function, the screen of CM100_DEBUG_MONITOR.exe is shown below. The end of content of debug messages will be separated by some equal marks. When newer debug messages are got by CM100_DEBUG_MONITOR.exe, they will be put in the end of these equal marks.

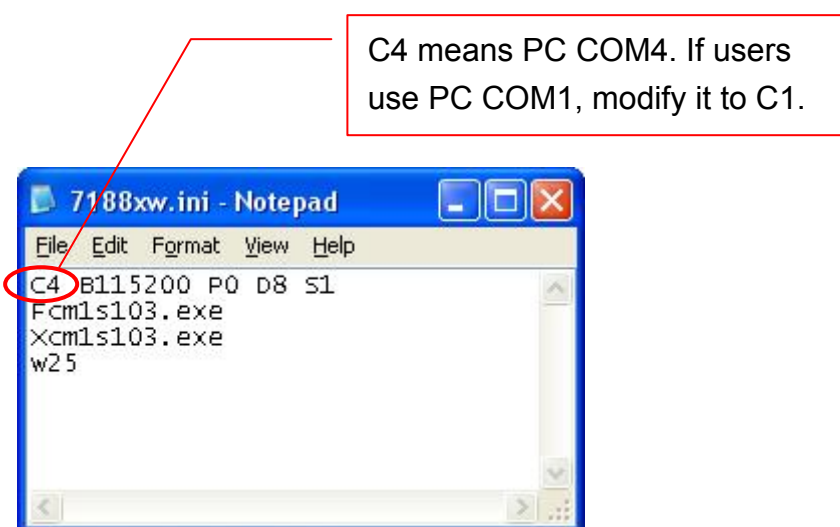


7188xw.exe:

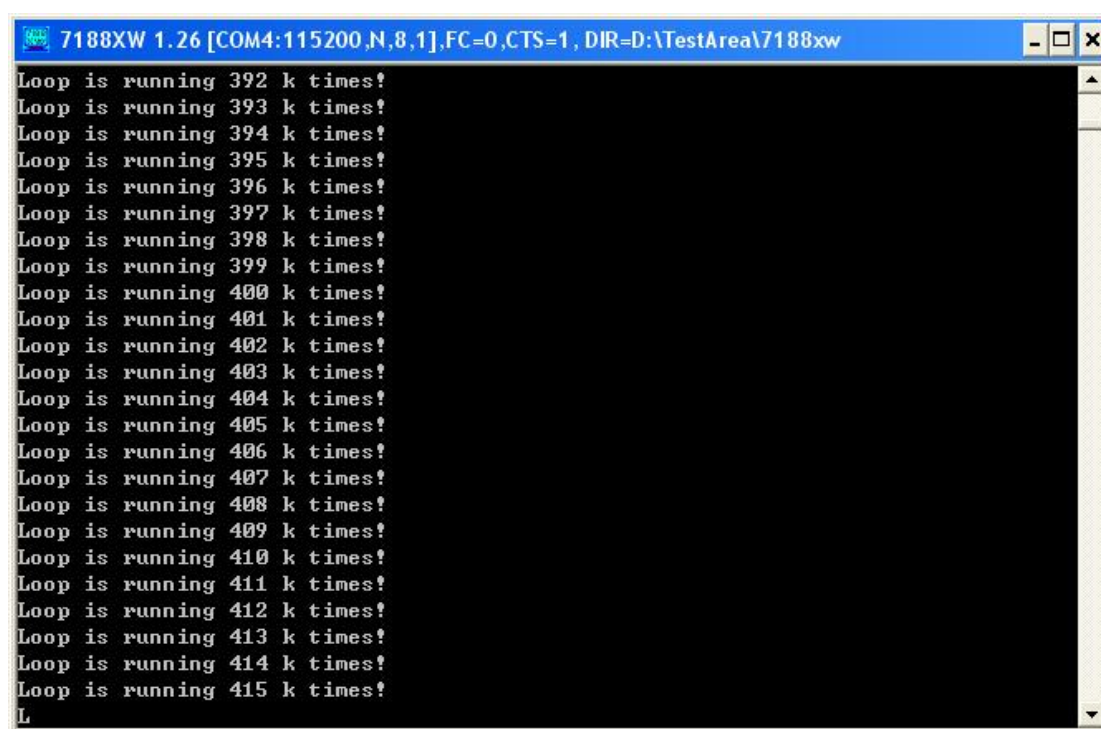
If users would like to use this method to debug, the firmware library provides two functions for applying. The function GetKbhit() allows users to received a inputted character from 7188xw.exe. Therefore, users can use this feature to trigger some specified event for debugging. The function Print() allows users to send debug messages to 7188xw.exe. Then, 7188xw.exe will put these debug messages on the screen of 7188xw.exe. Before implementing this method, users need to use the debug cable. Plug the debug cable to the JP4 of PISO-CM100-D/T described in section 2.2. Connect an available PC COM port with the D-Sub 9-pin connector of debug cable. The situation is shown as following figure.



Then, use Notepad.exe to configure the 7188xw.ini to set the number of specified PC COM port which is connecting with debug cable, and execute 7188xw.exe. The configuration screen is displayed as following figure. Users can find 7188xw.ini and 7188xw.exe in the Field Bus CD. The path is CAN\PC\PIISO-CM100\.



Then, any keyboard input will be caught by user-defined firmware via GetKbhit() function. The debug messages sent by Print() function will also be displayed on the screen of 7188xw.exe.



6.4 User-defined Firmware Programming

If users just apply default firmware for their application, this section can be ignored. This section describes about how to build a user-defined firmware. A CAN application can be implemented corresponding to the good cooperation of Windows application and the user-defined firmware. Generally speaking, the user-defined firmware processes the part of CAN communication protocol and some algorithms of input and output. The Windows application gets the processed data from user-defined firmware and shows them on user interface. Or, give a command to user-defined firmware to do some specified process. The relationship between Windows applications and the user-defined firmware is shown as the following figure.

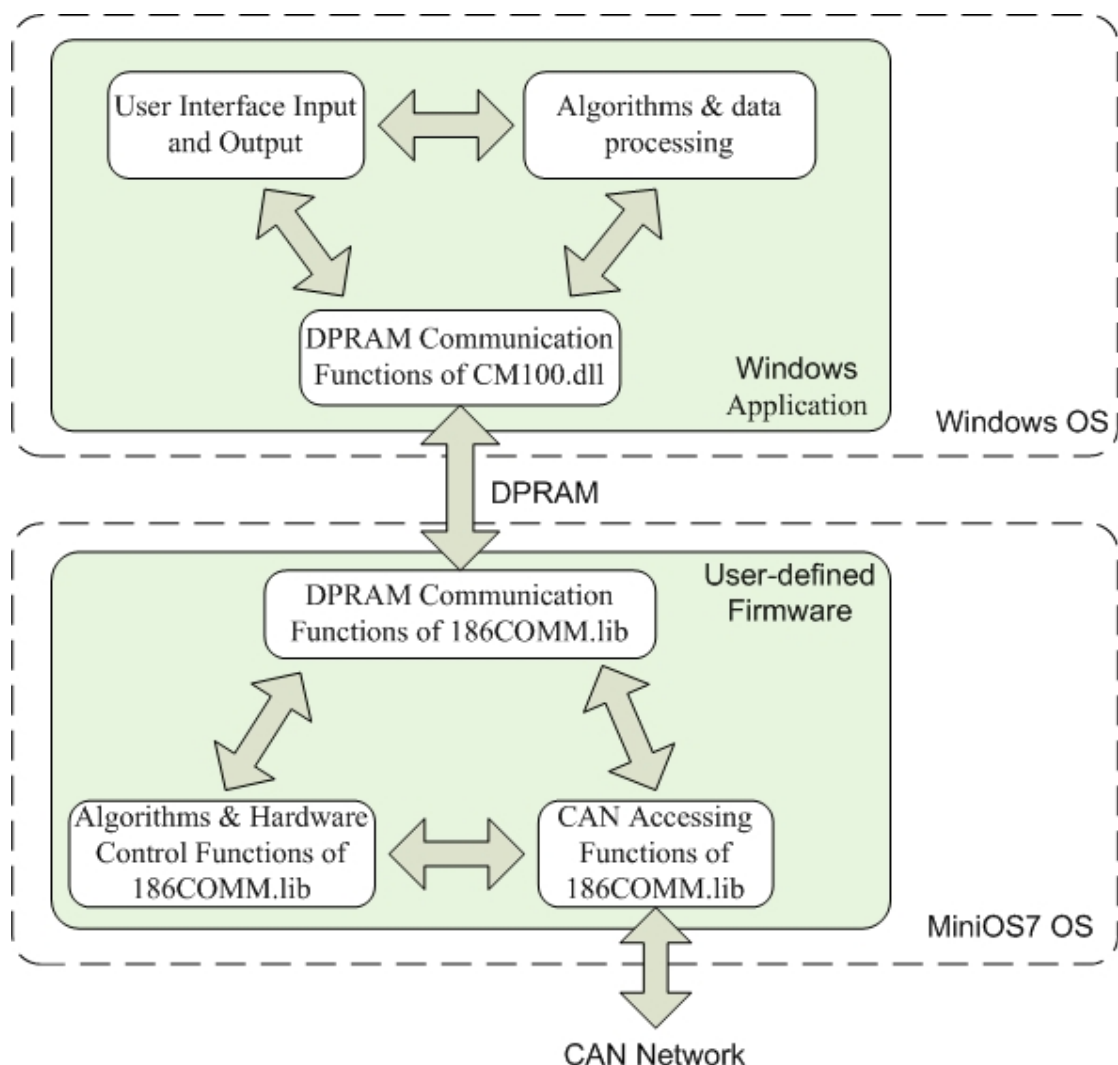


Figure 6.7 Relationship Between Windows Application & User-defined Firmware

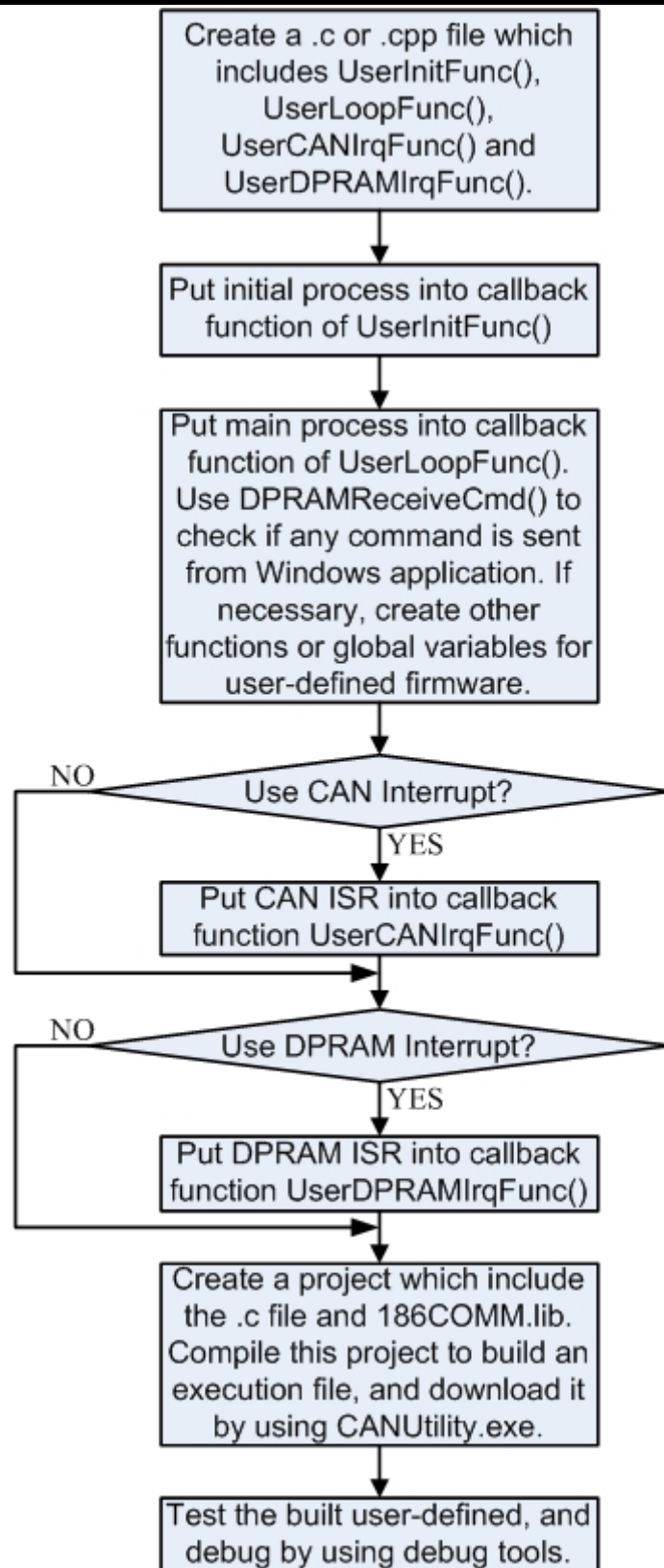


Figure 6.8 Development Procedure of User-defined Firmware

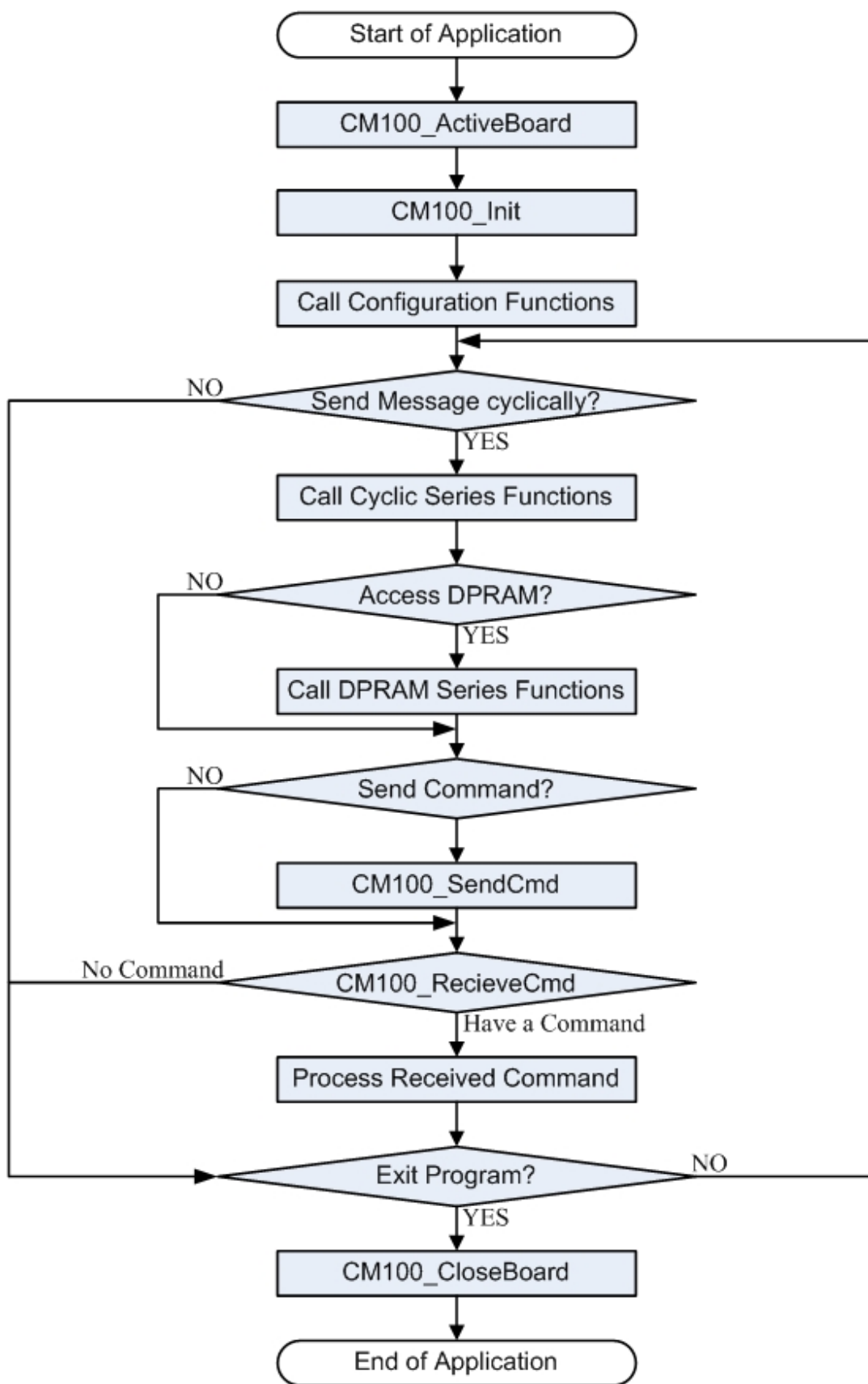


Figure 6.9 Procedure of Windows Application for User-defined Firmware

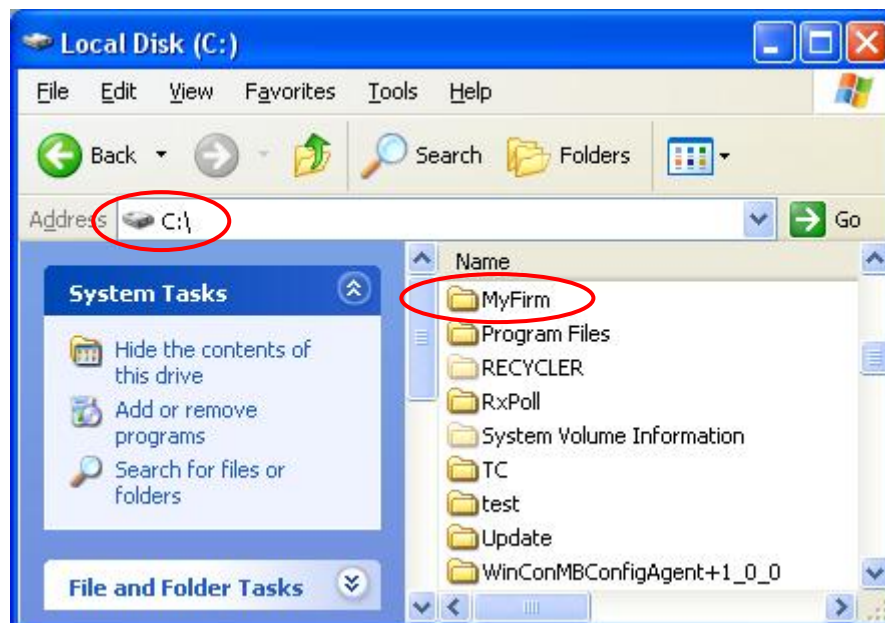
The Figure 6.8 and 6.9 shows the basic flowchart of developing the user-defined firmware and Windows application for user-defined firmware. For user-defined development, users can create a C/C++ project, and include several .c file and 186COMM.lib. Put the 4 callback functions in one of these .c file. Program the codes into these 4 callback functions. If necessary, build your functions and global variables. Then, compile this project, and you can get your user-defined firmware. Download it by using CANUtility.exe and test it. Afterwards, according to the functions of user-defined firmware, design your Windows application to match it. We provide some communication functions in the firmware library, 186COMM.lib. By using these functions, users can communicate windows application with user-defined firmware via DPRAM. Besides, firmware library also supports most functions of hardware on PISO-CM100-D/T, such as DPRAM accessing, EEPROM accessing, RTC access, timer function... and so forth. In the Windows application, the communication functions are also given by CM100.dll. Moreover, it also provides some useful functions, such as cyclic transmission engine, hardware reset function, SJA1000 configuration functions, DPRAM accessing... and etc.

When you want to design a Windows application, the BCB, VC++, or VB development environment are needed. Users can refer to the textbook of BCB, VC++ or VB for more information about how to use the APIS of .dll library in these development environments. About the user-defined firmware, users can use BC/BC++/TC/TC++ to build it. Here, it is considered that how to build an execution file with 186COMM.lib by using TC++1.01 compiler. Before starting the step-by-step procedure, users need to install TC++1.01 compiler and PISO-CM100-D/T Windows driver. Users can free download the TC++1.01 compiler through the following website.

<http://www.icpdas.com/download/download-list.htm>

The PISO-CM100-D/T Windows driver can be found in Field Bus CD or our website. Please refer to chapter 3 for more detailed information. The following paragraph is a step-by-step description about how to build your user-defined firmware. It may be a good model for development a user-defined firmware.

Step1: Create a folder named “MyFirm” in the C disk.



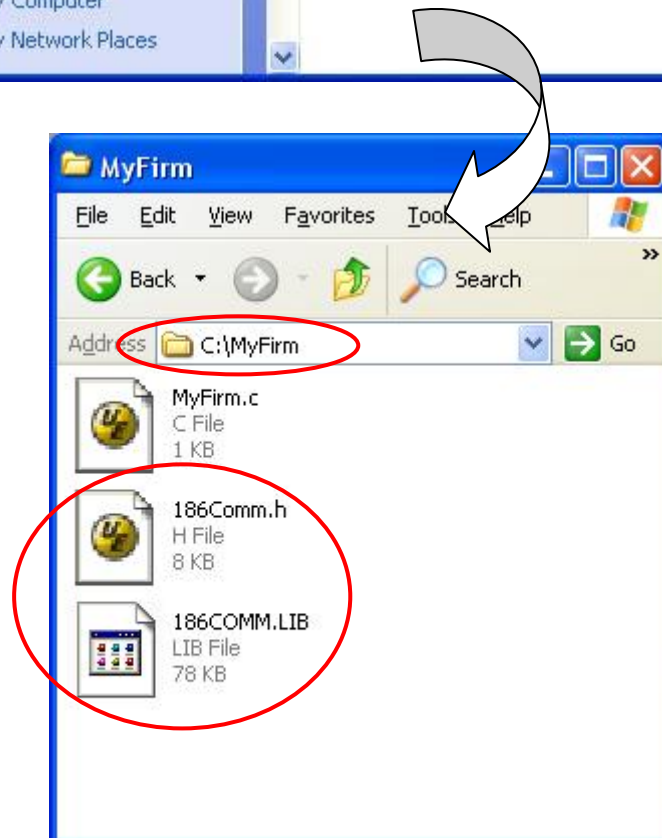
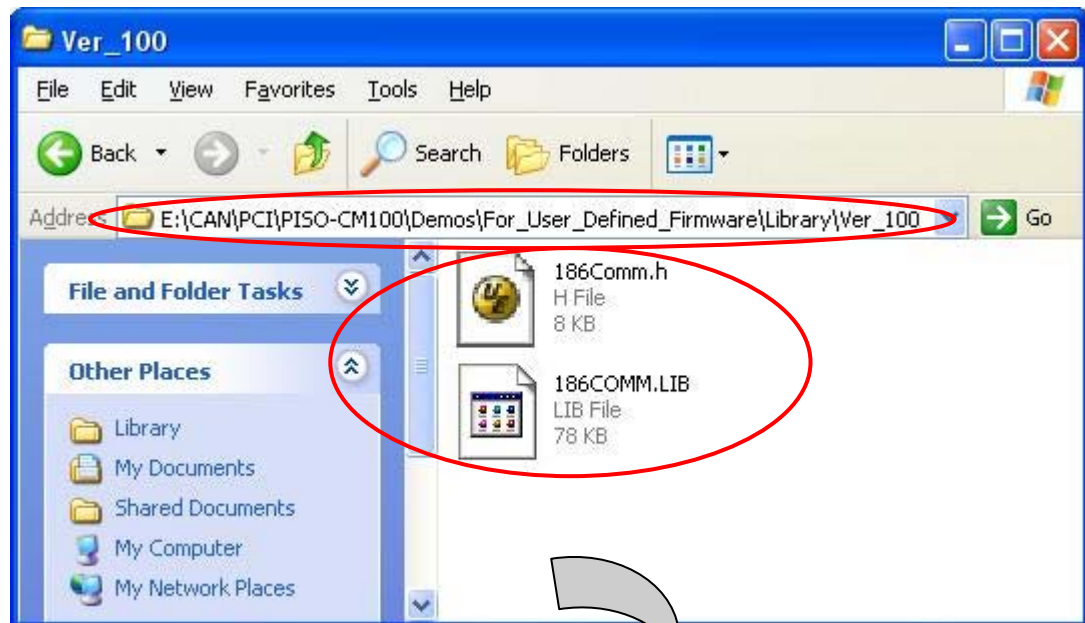
Step2: In the folder MyFirm, create a .c file and name it as “MyFirm.c”. Design the MyFirm.c file as follows. The 4 callback functions must be used in user-defined function.

A screenshot of a Notepad window titled 'MyFirm.c - Notepad'. The code is as follows:

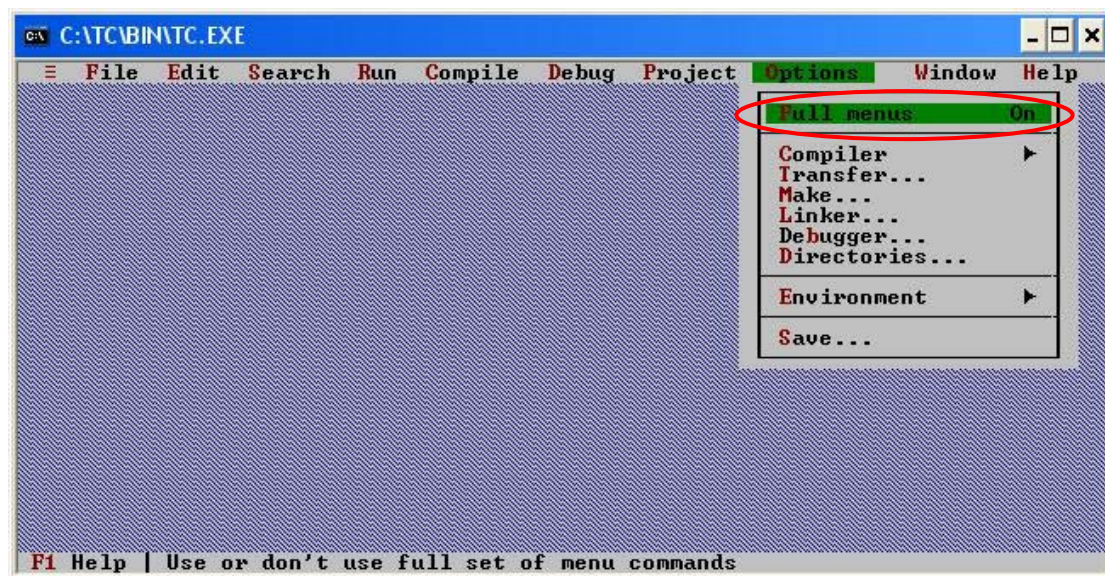
```
File Edit Format View Help
#include "186COMM.h"
unsigned long LoopCnt,MegaLoopCnt; //Global vairable
void userDPRAMIrqFunc(unsigned char INTT) //must be called
{
    //do nothing
}
void userCANIrqFunc(unsigned char INTT) //must be called
{
    //do nothing
}
void userInitFunc(void) //must be called
{
    Print("MyFirmware is running...\r\n");
    DebugPrint("MyFirmware is running...\r\n");
}
void userLoopFunc(void) //must be called
{
    if (++LoopCnt==1000UL){
        MegaLoopCnt++;
        Print("Loop is running %lu k times!\r\n",MegaLoopCnt);
        DebugPrint("Loop is running %lu k times!\r\n",MegaLoopCnt);
        LoopCnt=0;
    }
}
```

The following lines are circled in red: `#include "186COMM.h"`, `void userDPRAMIrqFunc(unsigned char INTT) //must be called`, `void userCANIrqFunc(unsigned char INTT) //must be called`, `void userInitFunc(void) //must be called`, and `void userLoopFunc(void) //must be called`.

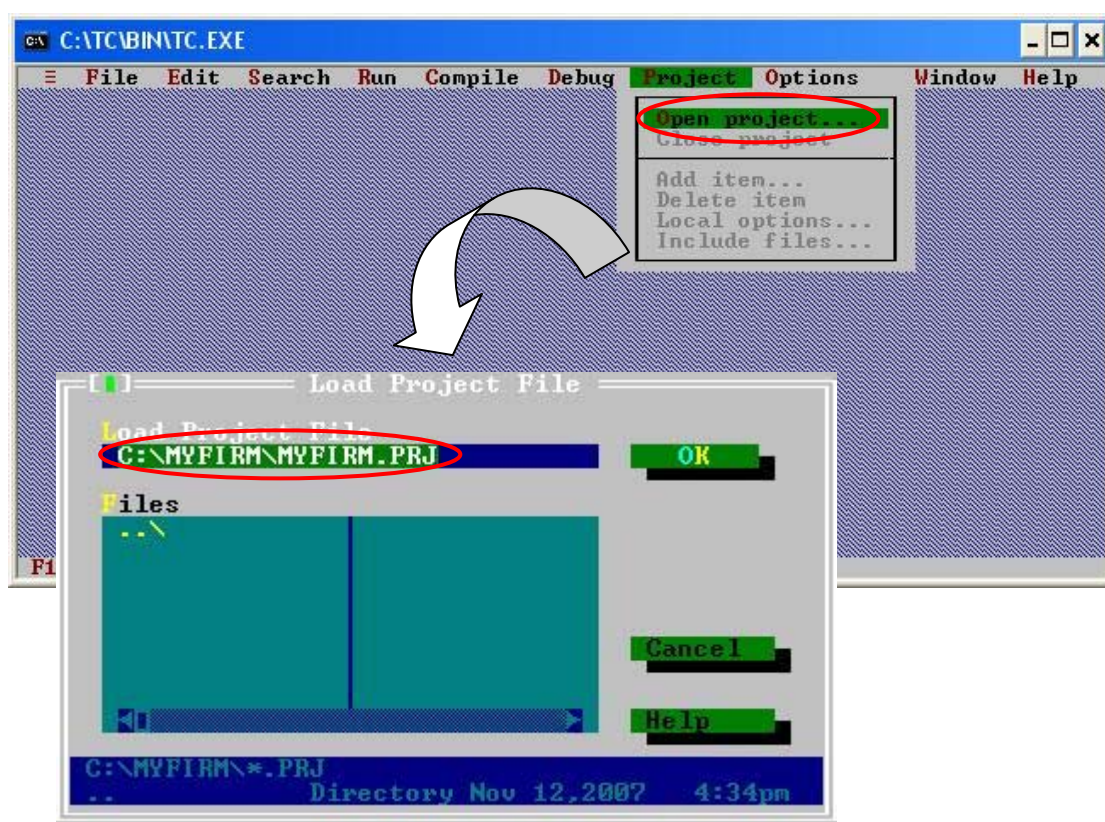
Step3: Copy 186COMM.lib file and 186COMM.h file into MyFirm folder. Users can find them with version 1.00 in the path CAN\PCI\PISO-CM100\Demos\For_User_Defined_Firmware\ver_100 in Field Bus CD.



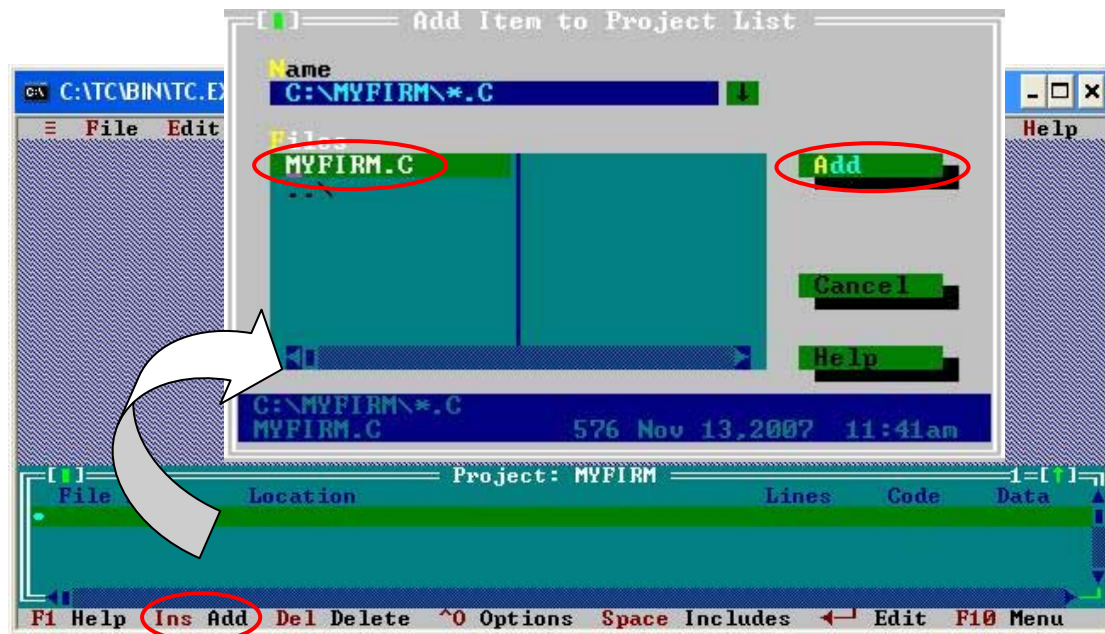
Step4: Run the TC++1.01 development environment. Click the “Options\Full menus” to expand the all functions list in the menu.



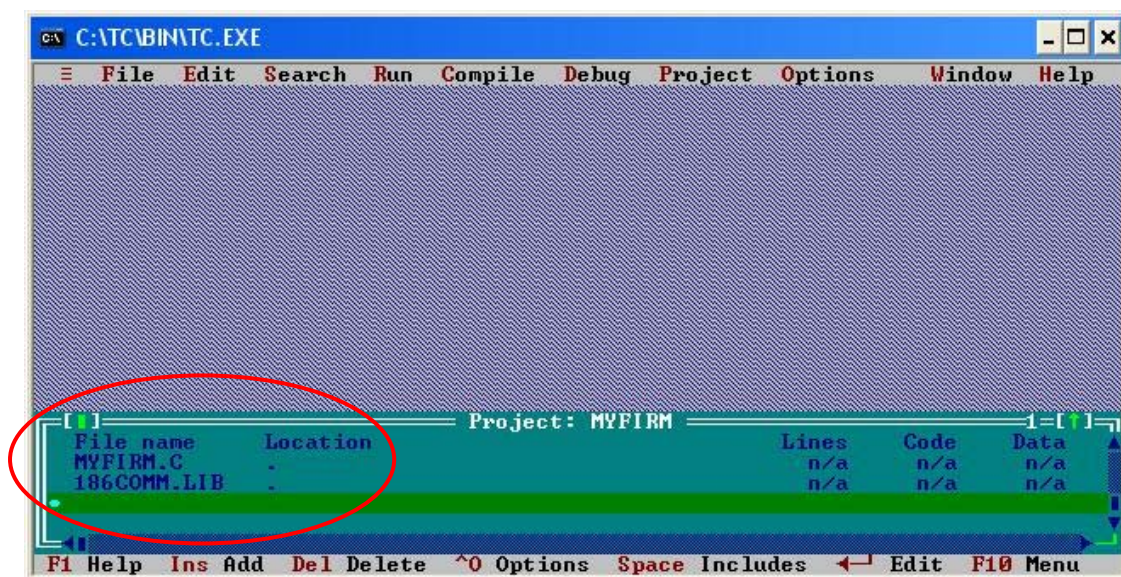
Step5: Click the “Project\Open project...” to create a new project. Input the project name “MyFirm.PRJ”, and click OK button to continue.



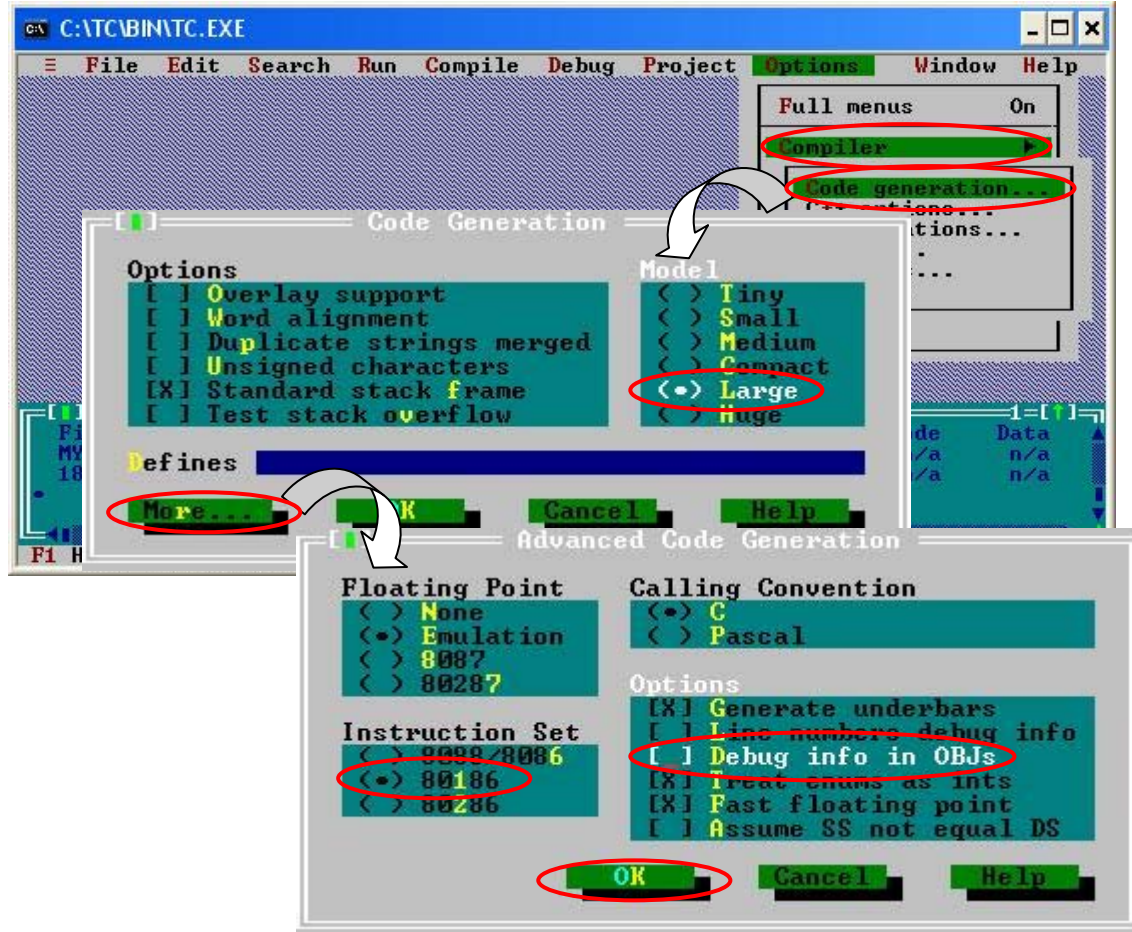
Step6: Click “Add” function on the bottom of TC++1.01 screen. Search all .c file by setting c:\MyFirm*.c in the Name field of popup window. Then, use the “Add” button to add the MyFirm’ .c file in to MyFirm project. Then, change the search command from “c:\MyFirm*.c” to “c:\MyFirm*.lib” in the Name field. Add the library files 186COMM.lib into MyFirm project by the same way.



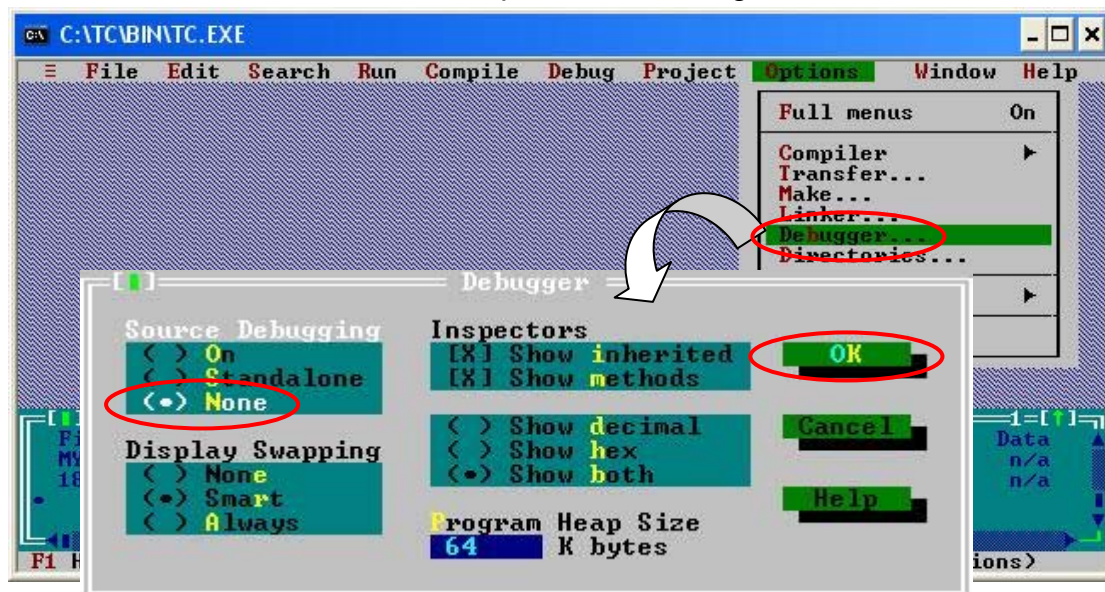
Step7: After finishing the Step6, the TC++1.01 window will look like as follows.



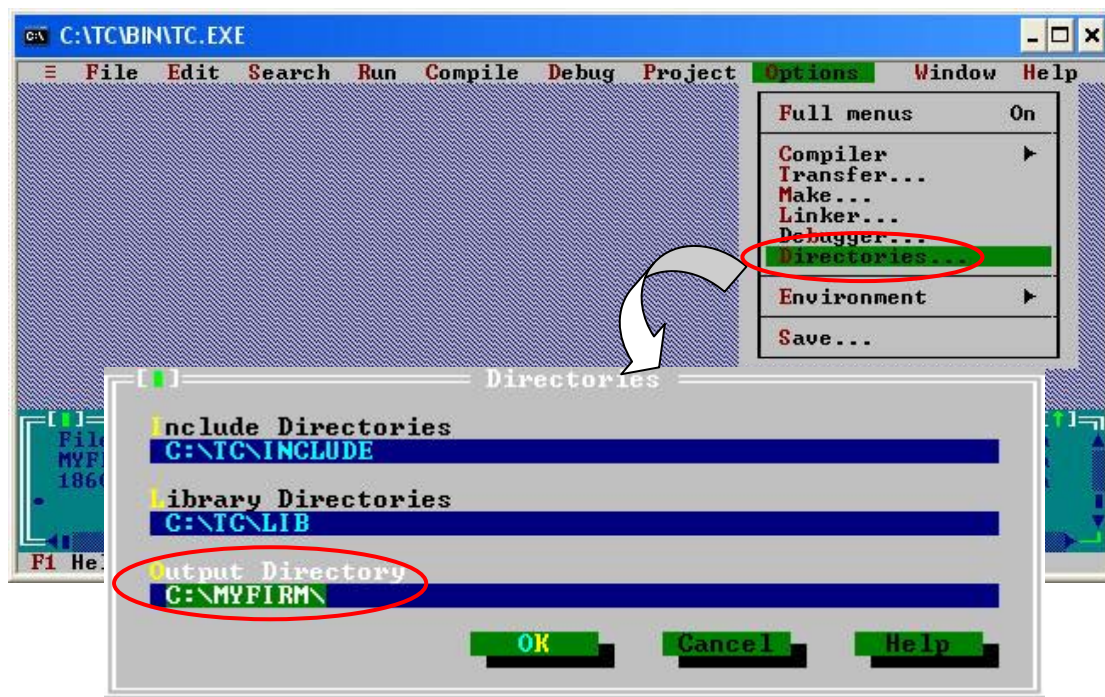
Step8: Click the “Options/Compiler/Code generation...” to set the compiler model to the large mode. Afterwards, click “More...” to set the “Floating point” and “Instruction Set” parameters, the Emulation and 80186 item will be used respectively. Then, click OK to save the configuration.



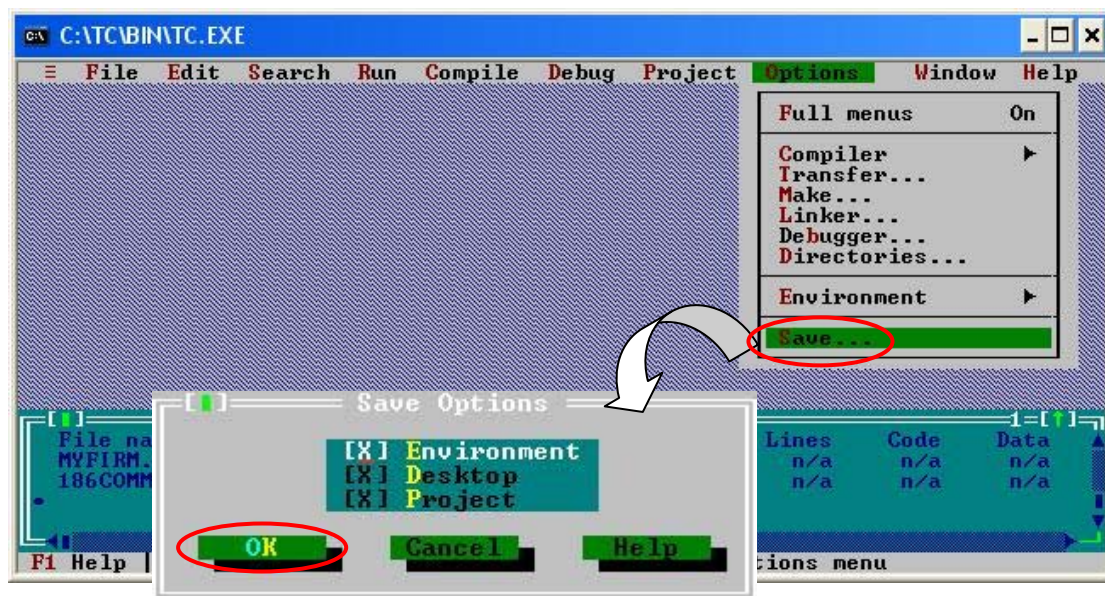
Step9: Click the “Option/Debugger...” to set the “Source Debugging” parameter. Here, select “None” for this parameter setting.



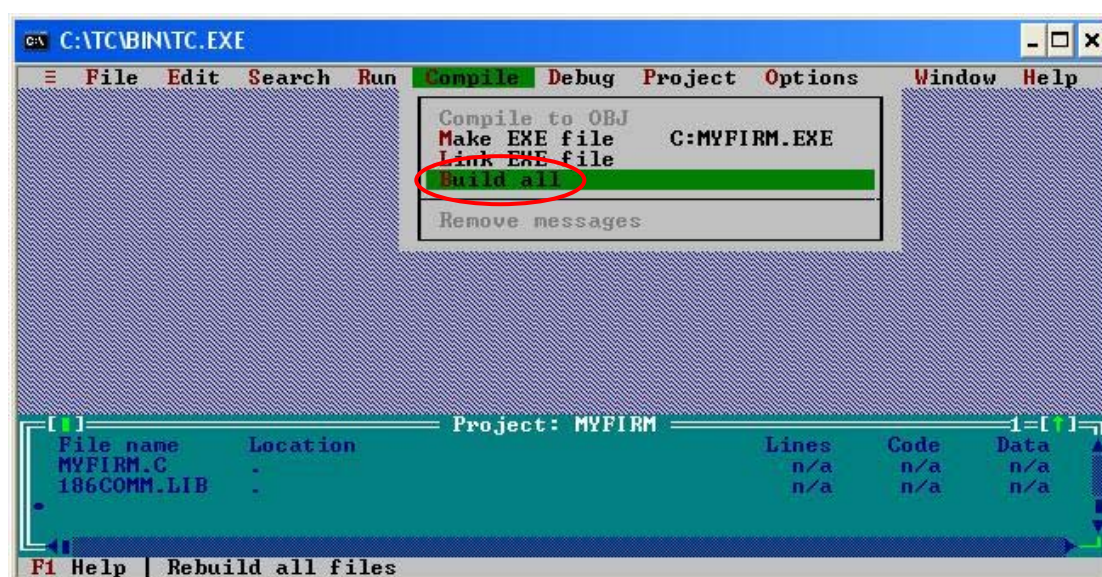
Step10: Click the “Option/Directories...” to set the “Output Directory” parameter.
Here, set the “C:\MyFirm” for the “Output Directory” parameter.



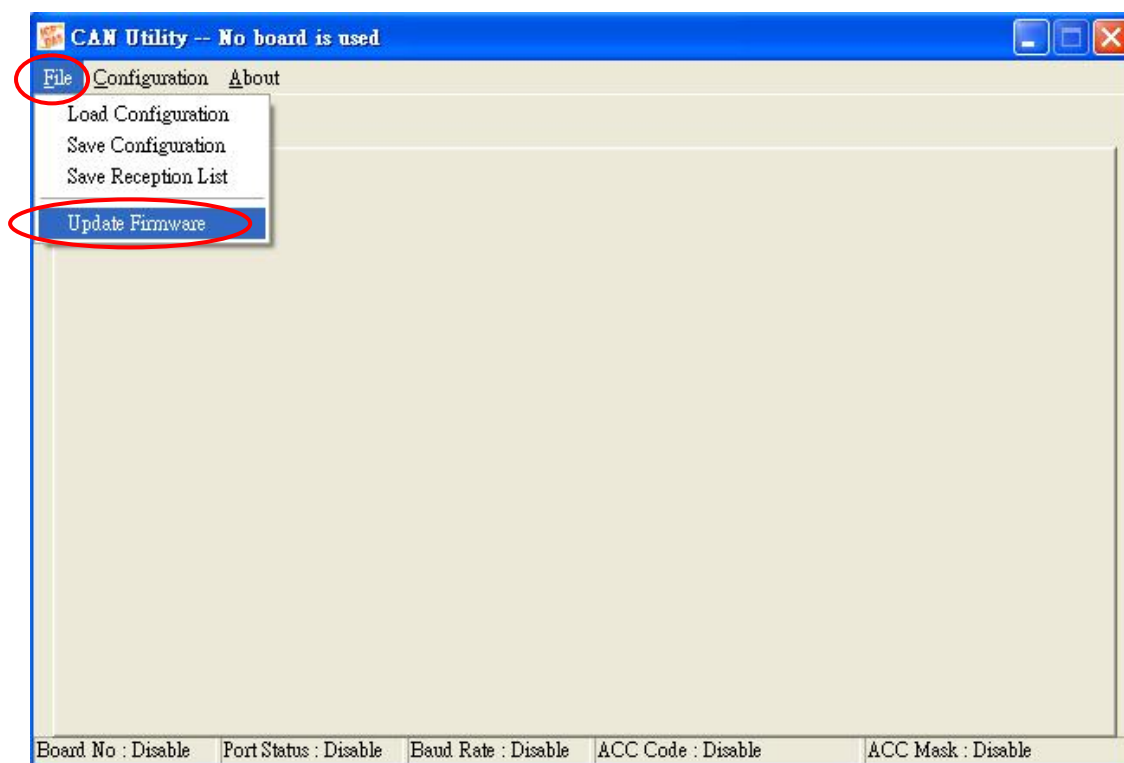
Step11: After finishing the parameters setting, click the “Options/save” to save this project.



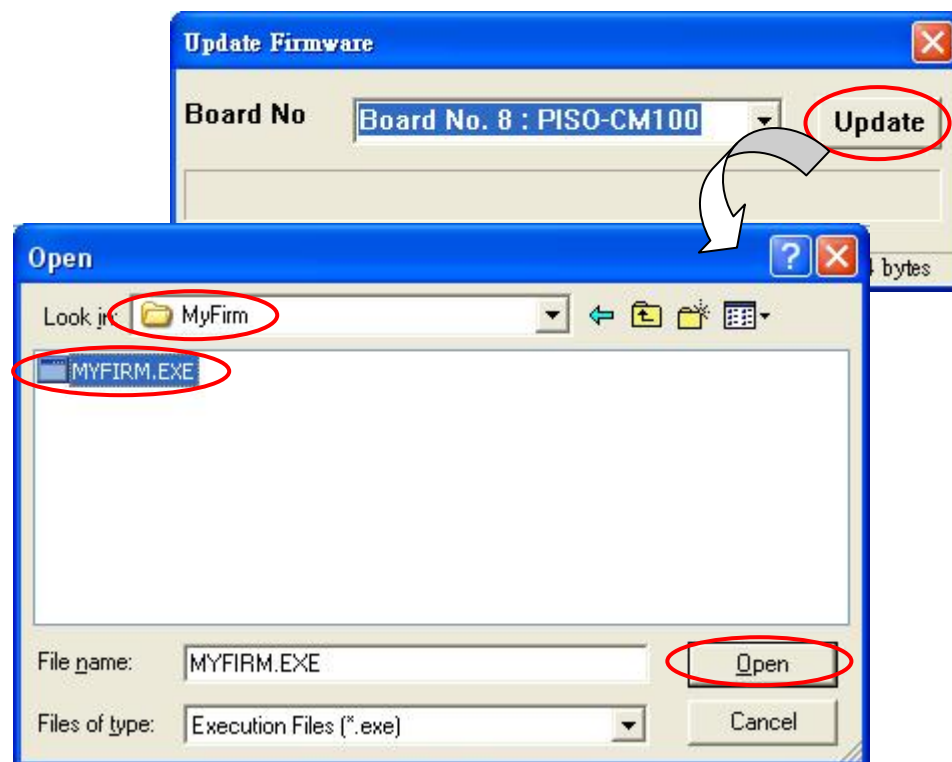
Step12: After finishing the parameters setting, click the “Compile/build all” to produce the execution file. Users can find the execution file in the MyFirm folder. Its name is MyDemo.exe. The warning messages may occur during the compiling procedure because the INTT parameters of UserCANIrqFunc() and UserDPRAMIrqFunc() are not used. These warning will not have any affection to user-defined firmware.



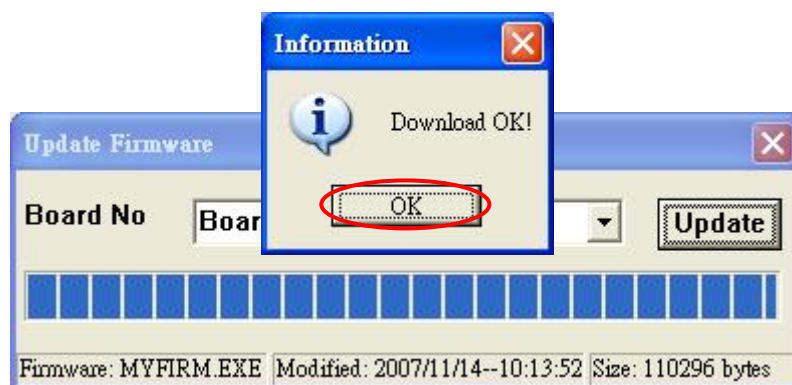
Step13: Execute CANUtility.exe, and select File\Update Firmware to download the user-defined firmware.



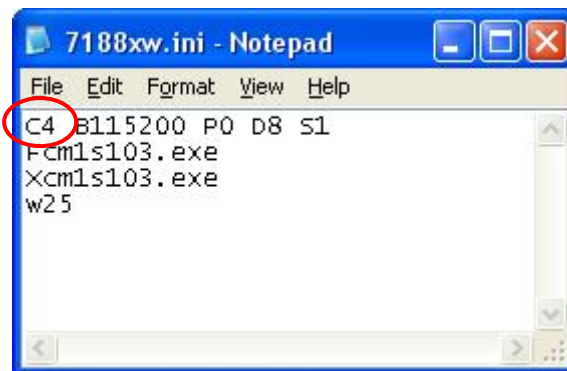
Step14: Select the board name, click Update button, and find the MyFirm.exe from dialog.



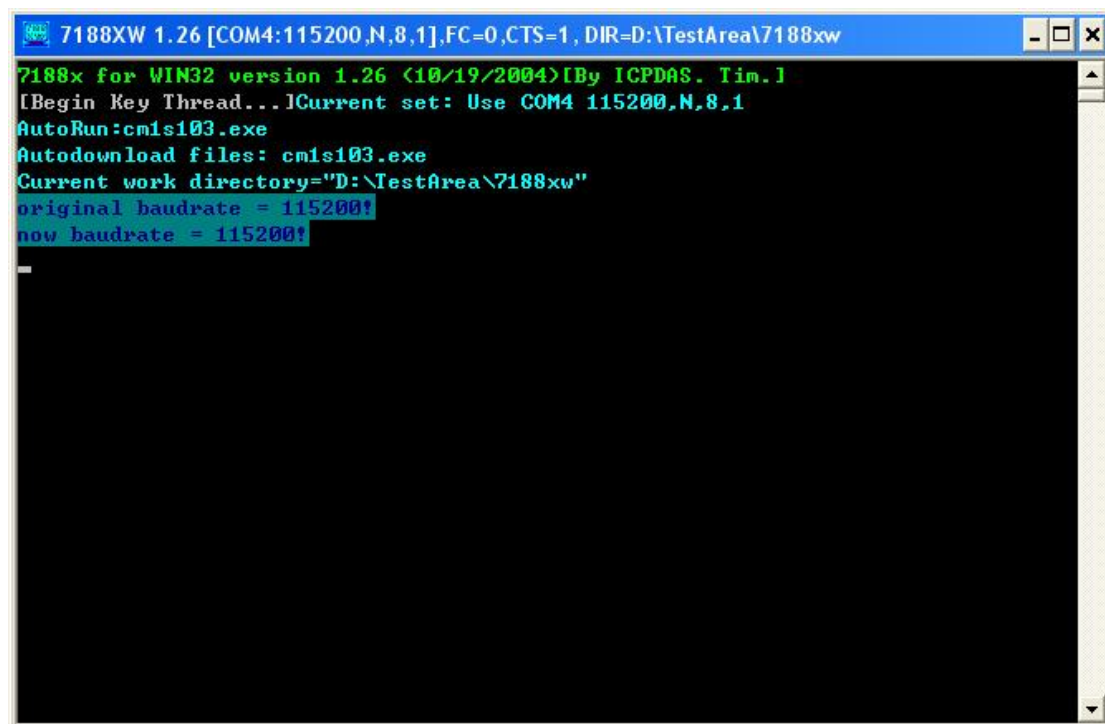
Step15: When finishing, the Download OK messages is shown.



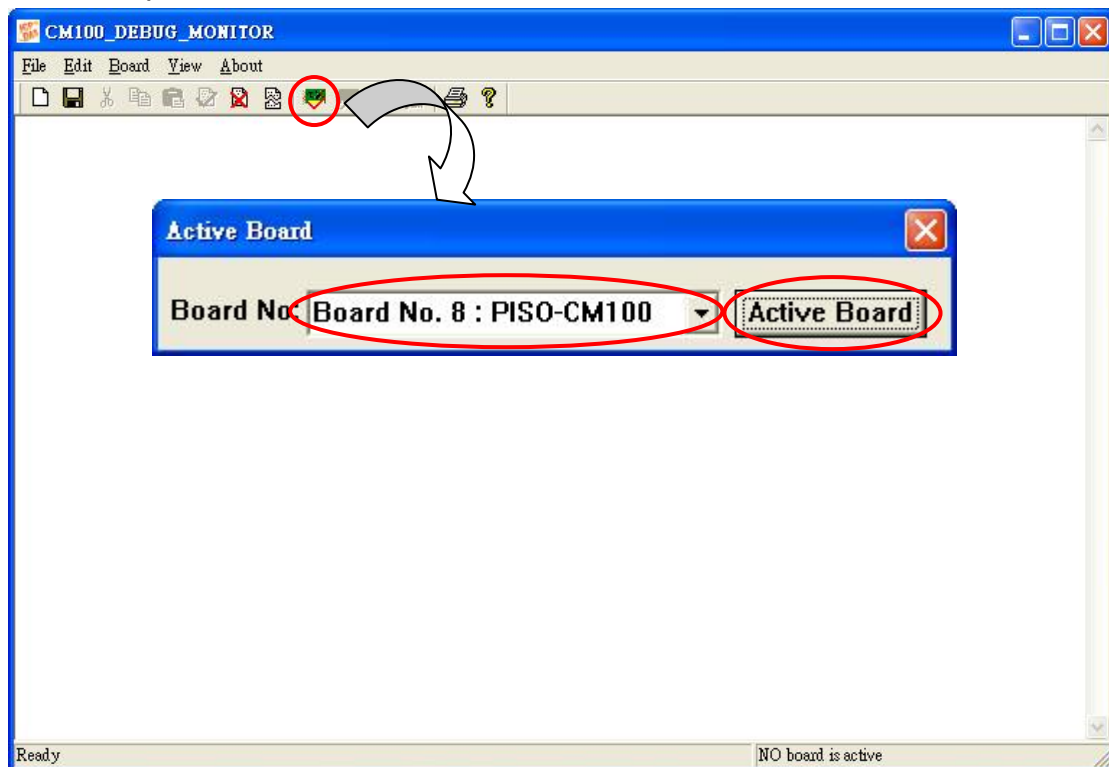
Step16: Check the 7188xw.ini. Here, use PC COM4 to connect the debug cable of PISO-CM100-D/T. Therefore, set the COM No. value to "C4". If users use COM1, set the value to "C1". Users can find 7188xw.ini and 7188xw.exe in the driver installation path. The default installation path is "C:\ICPDAS\PISO-CM100\".



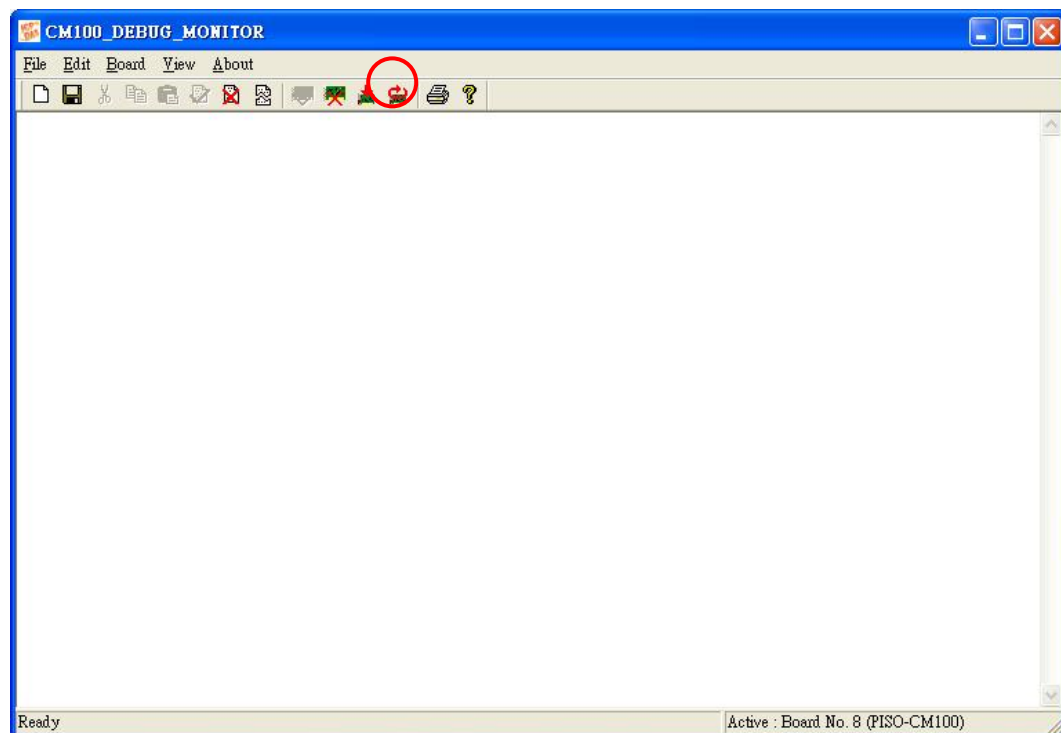
Step17: Execute 7188xw.exe.



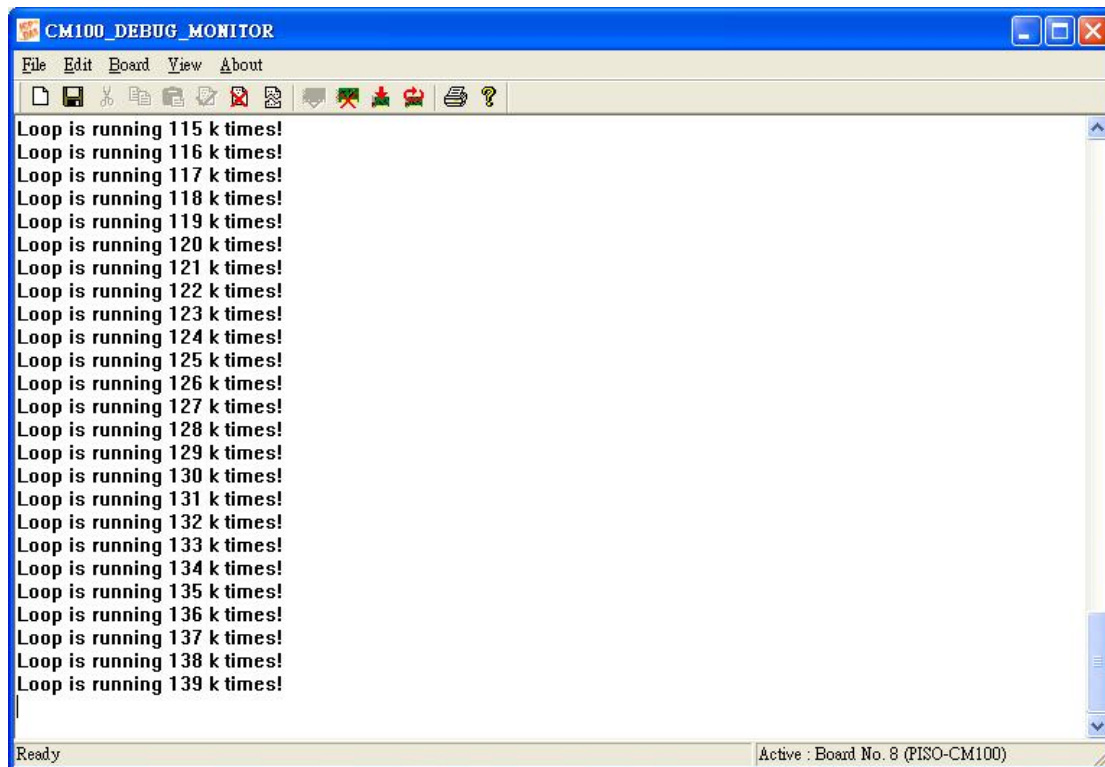
Step18: Execute CM100_DEBUG_Monitor.exe. Users can also find it in the driver installation path. Then, click Active Board icon, and active the specified board.



Setp19: Click the Hardware Reset icon after activating the specified board.



Step20: Check the CM100_DEBUG_MONITOR.exe, user can find the debug messages from user-defined firmware.



Step21: The 7188xw.exe also has the debug messages from user-defined firmware.

